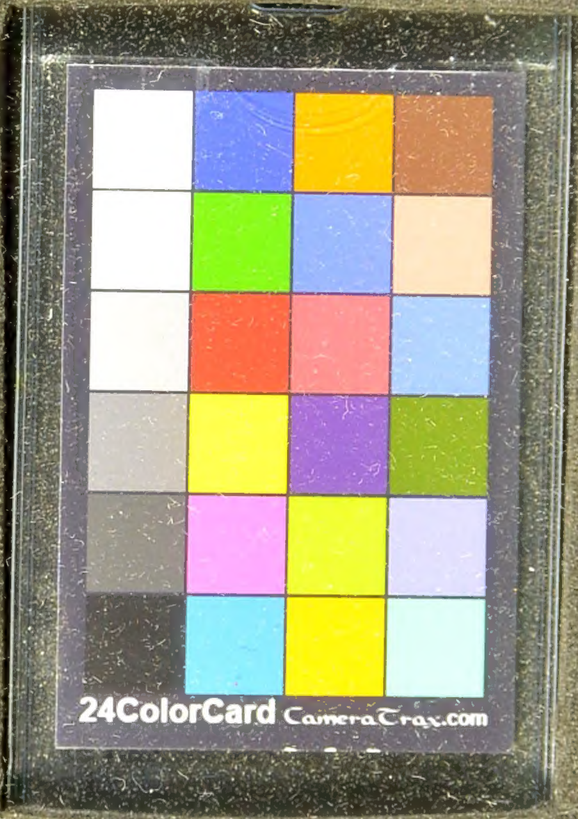
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PUBLIC HEALTH

BY

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PREFACE

This volume is the outcome of the division of the subjects contained in the author's "Text-Book of Medical Jurisprudence, Toxicology, and Public Health." The demands of the modern growth of these subjects compelled the author to divide them, and accordingly, he issued a first volume dealing with Medical Jurisprudence and Toxicology some months ago. The section dealing with Public Health, which constituted the Second Part of that text-book, now reappears in this volume.

The author has reason already to believe that this change has been of advantage to students and practitioners alike, so far at least as the first volume is concerned. He hopes that the present volume will also prove acceptable to those more especially interested in Public Health.

He has followed in this volume the same general arrangement of subjects as in the original treatise. Each division of the subject has been amplified and brought into line with present advancements. The work, as a whole, has accordingly been largely re-written, and has undergone considerable enlargement, not only by matter being added to those subjects which were formerly treated, but also by the inclusion of new subjects.

In particular, there has been introduced a fairly full treatment of Sanitary Law. From his experience as a teacher of Public Health during the past twenty-five years, he has found that the average student is less attracted to this part of the subject than to the others. That, he believes, is in the main due to the fact that Sanitary Law has had hitherto to be studied in separate works, the law being thus divorced from its application. In this work, the author has followed the line of his teaching, and has attempted to correlate the law to each division of the subject treated of in the text. Thus in regard to air-supply, water-supply, sewerage and disposal of sewage, and infectious diseases, for example, the law relating to the same is set down after the discussion of the subjects of air, water, sewage, and infectious diseases respectively. The effect is that the student will find to his hand the law dealing with each branch of the subject, instead of having to read two or more books or many Acts of Parliament which bear on these subjects separately. Moreover, where the subject lends itself to such treatment, the author has instituted a comparison of the law of England with the law of Scotland, and in many instances also with the law of Ireland, respecting several branches of sanitary legislation. While this has involved no little labour, he hopes that such a method of treatment will prove of assistance to the student. In this respect, perhaps, the present volume differs from most text-books dealing with Public Health.

The author has refrained from introducing to any great extent in this work illustrative legal cases, owing to the relatively large amount of space required to present an adequate account of the bearings of each case, his intention being to keep the book within the limits of a handy text-book.

In addition, there has been introduced in the book the law respecting Rivers Pollution, Factories and Workshops, Isolation Hospitals, Nuisances, Offensive Trades, Diseases of Animals, the Sale of Foods and Drugs, Dairies, Milkshops, and Cowsheds, the Disposal of the Dead, and various other subjects.

In preparing the volume for his readers, the author has most gratefully to acknowledge his great indebtedness for assistance in reading proofs and otherwise to his friends Alexander Duncan, Esq., B.A., LL.D., Secretary and Librarian to the Royal Faculty of Physicians and Surgeons of Glasgow, and to Dr Alexander Walker of Edinburgh.

In conclusion, he further desires to express his acknowledgments to the publishers, who have spared neither time, trouble, nor expense in presenting the volume to his readers.

University of Glasgow,
November 10*th*, 1910.

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SECTION III

PUBLIC HEALTH

CHAPTER I

INTRODUCTORY SKETCH

FROM the days of the Mosaic Code up till the present time, the science of medicine has been divisible into two distinct branches—viz. the curative, and the prophylactic or preventive. It is interesting to note that in the Code above mentioned probably more attention is devoted to the prophylactic than to the curative aspect, for there are laid down not only the doctrines of quarantine or isolation in infectious disease, disinfection and destruction of infected material, but also the doctrines of preventive medicine in respect of food-supply, more especially with reference to flesh-meat. Indeed, in this last respect, while the reasons of the law-giver respecting the animals whose flesh might or might not be eaten are not clearly given, modern research has demonstrated that, as regards the flesh of the pig, at least, the precautions laid down were salutary. For many centuries these principles have been kept in active use by the Jewish people, and in the Talmud are laid down the regulations whereby only healthy meat may be used for consumption, and suspicious or diseased meat rejected. While in these modern days attempts are being made to secure the like result by inspection of meat in our abattoirs, it is because long and painful experience by the nations has demonstrated its need. If we turn to the Fathers of Medicine—Hippocrates, Galen, Celsus—we find that they were not unmindful of the prophylactic side of the art, and that they recognised the value of fresh air, food, rest, exercise and other factors in the cure and recuperation of man. In the Middle Ages, however, it would appear as if such principles had been entirely forgotten, or were neglected. People flocked within walled cities for protection, and plague and pestilence followed in their train. Such epidemics, fatal and extensive in their character and incidence, while they had their undoubted origin in the neglect of the very elements of sanitation, were not recognised as due to such neglect, and in those superstitious times were reckoned to be the result of supernatural causes. While such ignorance obtained generally regarding the causal relationship of insanitation and disease, enlightened rulers and physicians arose, however, from time to time who saw the connection, and who fell back upon the Jewish regulations for the stay of such plagues and pestilences. Bernardo, the ruler of Reggio, for example, was among the first to set in force the Jewish Code when the Black Death broke out in Italy in the fourteenth century, in the course of its devastating progress through the continents of Asia and Europe. Having started in Asia, it broke out in Italy in 1348, reached England in August of that year, and was in London in November. From this epidemic it has been estimated that in Europe alone twenty-five millions of people were killed. Boccaccio, in the Induction to the "Decamerone," gives a minute account of its outbreak in Florence, and from his detailed clinical account of the appearances on the bodies of men and animals attacked by it, there can be no doubt of its identity with the Plague.

In the fifteenth century (1485) the Venetian laws of quarantine were framed, the term " quarantine " being derived from the Italian word *quaranta*, signifying forty, a period of forty days being the period of isolation laid down in the Mosaic Code.

For more substantial advance in sanitary principles, however, we must look to the eighteenth century. Inoculation against small-pox was introduced into England by Lady Mary Montagu in 1722; better ventilation of public buildings and of ships was initiated by Desaguliers and Samuel Sutton; Sir George Baker made researches into the cause and prevention of lead colic; Captain Cook discovered in his voyage round the world the means of preventing scurvy in his ships' crews by the regular use of lime-juice; John Howard did his noble work with reference to the improvement of prisons and gaols—which were then the hot-beds of typhus fever; and, last of all, there was the great discovery by Jenner, in 1798, of the protective influence of vaccine virus against small-pox. As the nineteenth century advanced, and by reason particularly of the first visitation of cholera to Great Britain in 1832, it became necessary that some special sanitary legislation should be enacted. The beginning of the century saw the basis of health statistics established, by Parliament passing an Act for the taking of a census of the inhabitants in 1801. This was only accomplished after nearly fifty years' debate and discussion, as the original proposal to effect this was made by Mr. Thomas Potter in 1753. The census, however, was not complete until 1834, when the poor-law districts were thoroughly revised; hence the first complete statistical figures only date back to the Registrar-General's Returns in 1836. The first outbreak of cholera in this country in 1832, which was imported to Newcastle from Hamburg, and which spread throughout these islands, compelled the attention of the Government, and the Privy Council in that year put in force a measure for preventing the spread of the disease by amending the Quarantine Act. In the same year a Royal Commission on the Poor-Laws was appointed, out of which came the Poor-Law Amendment Act of 1834. In 1833 the Lighting and Watching Act was passed, and also the first amended Factory Act. In 1836 came the Registration Act; in 1840–1841, the Vaccination Act; in 1846, the Removal of Nuisances Act; in 1846–1848, the Baths and Wash-Houses Act; and in 1847, the Towns Improvement Clauses Act, and the Towns Police Clauses Act. Before this, however, in local Police Acts control was obtained by the authorities of certain populous places respecting filth-removal, overcrowding, and other like conditions, all of which tended to sanitary improvement. Glasgow, for example, in its Police Act of 1834 obtained these powers. Owing to the labours of Edwin Chadwick with reference to the sanitary condition of large towns, Sir Robert Peel appointed a Royal Sanitary Commission to inquire into the condition of large towns, etc., and the Reports which issued from this Commission caused the passing of the Public Health (England) Act of 1848, and the Nuisances Removal and Disease Prevention Acts, with an amendment of the latter, in the following year. Great Britain experienced its second outbreak of cholera in 1848–1849, and a Board of Health was thereupon constituted to supervise sanitary affairs. It effected the passing of several sanitary measures—viz. the Metropolitan Interment Act of 1850, the Burial Act of 1853, the Common Lodging-Houses Act of 1851–1853, and the Metropolitan Water Act of 1852. The third outbreak of cholera was experienced in 1853–1854. Several sanitary measures were thereupon consolidated—viz. the Nuisance Removal Act of 1854, the Diseases Prevention Act of 1855, with amendments in 1860, 1863, and 1866. The Local Government Act was passed in 1858, with amendments in 1861–1863; the Adulteration of Foods Act in 1860; the Alkali Works Acts in 1863–1868; the Sewage Utilisation Acts in 1865–1867, Sanitary Acts in 1866, 1868, 1870, with the Sanitary Loans Act in 1869. The Public Health (Scotland) Act was passed on 15th August 1867, with amendments in 1871 and 1879; and in the year 1867 the Factory Extension Act, with the Artisans' and Labourers' Dwellings Act in the following year. Another Royal Sanitary Commission was appointed in 1869–1870, and the principal Sanitary Acts succeeding its work were: The Local Government Board Act, 1871; The Public Health Act, 1872; the Public Health (England) Act, 1875; the Artisans' Dwellings (Scotland) Act, 1875; the Rivers Pollution (Prevention) Act, 1876; the Canal Boats Act, 1877; and the Public Health (Ireland) Act, in 1876, with the Public Health (Water) Act, in the same year. In 1866 the Glasgow Improvements Act was passed, which formed the model for the Artisans' and Labourers' Dwellings Act of Sir Richard Cross (first Viscount Cross). Since that time several new and amending Acts have been passed, in addition to Orders and Regulations, with the provisions of which a Medical Officer of Health must be familiar, in order that he may properly fulfil the duties of his office. The following list may be held to include the various Acts, etc., of which a Medical Officer of Health must have a working knowledge:—

I. SCOTLAND *only*—

(*a*) Public Health (Scotland) Acts, 1897, 1904, and 1907;

(*b*) Burgh Police (Scotland) Act, 1892; especially Part IV., which deals with Cleansing, Plans of new Buildings and Regulations, Ventilation, Drainage of Houses, Soil-pipes and Water-closets, Water-supply, Slaughter-houses,—Bye-laws, sects. 316 B, and 318; the Burgh Police (Scotland) Act, 1903; and the Burgh Sewerage, Drainage, and Water-supply (Scotland) Act, 1901;

(*c*) Vaccination (Scotland) Acts, 1863 and 1907;

(*d*) Dairies, Cowsheds, and Milkshops Orders, 1885, 1887, 1899;

(*e*) Regulations as to Cholera, Yellow Fever, and Plague, 1898;

(*f*) Local Government Acts, 1889 and 1894;
(*g*) Cattle Sheds in Burghs (Scotland) Act, 1866;
(*h*) Public Health (Regulations as to Food) Act, 1907;
(*i*) The Public Health (Foreign Meat) Regulations (Scotland), 1908;
(*j*) The Public Health (Unsound Food) Regulations (Scotland), 1908;
(*k*) Burial Grounds (Scotland) Act, 1855.

II. ENGLAND *only*—
(*a*) Public Health (England) Act, 1875;
(*b*) Public Health (Water) Act, 1878;
(*c*) The Cotton Cloth Factories Acts, 1889 and 1897;
(*d*) Public Health (Amendment) Acts, 1890, 1896 and 1907;
(*e*) Infectious Diseases (Prevention) Act, 1890; and The Epidemic and Other Diseases Prevention Act, 1883;
(*f*) Local Government Acts, 1888 and 1894;
(*g*) Isolation Hospitals Act, 1893 (Lord Thring's Act);
(*h*) Vaccination Act, 1867; and Amending Acts, 1871, 1874 and 1898;
(*i*) Canal Boats Acts, 1877 and 1884;
(*j*) Public Health (Interments) Act, 1879;
(*k*) Regulations as to Cholera, Yellow Fever and Plague, 1896 and 1902;
(*l*) Public Health (Ports) Act, 1896;
(*m*) Dairies, Cowsheds, and Milkshops Orders, 1885, 1887, and 1899;
(*n*) Model Bye-laws issued by Local Government Board;
(*o*) Midwives Act, 1902.

Sanitary Acts for the Metropolis of London, while passed separately, embody the provisions of the foregoing.

III. UNITED KINGDOM—
(*a*) Factories and Workshops Act, 1878;
    Part I. (1) Sanitary provisions;
    ,, II. (1) Sections 4 and 5;
    ,, IV., including first and second schedules;
(*b*) Factories and Workshops Acts, 1883, 1891 and 1895, in so far as they amend or extend sanitary provisions and provisions respecting health; and the Factory and Workshop Act, 1901;
(*c*) Sale of Food and Drugs Acts, 1875 to 1899;
(*d*) Margarine Act, 1887; Butter and Margarine Act, 1907;
(*e*) Sale of Horse-Flesh Regulation Act, 1889;
(*f*) The Alkali Acts, 1881–1892;
(*g*) Housing of the Working Classes Act, 1885 and 1890;
(*h*) Contagious Diseases (Animals) Act, 1878—section 34;
    ,, ,, ,, ,, 1886—section 9;
(*i*) Diseases of Animals Act, 1899;
(*j*) Infectious Diseases (Notification) Act, 1899;
(*k*) Rivers Pollution (Prevention) Acts, 1876 and 1893;
(*l*) The Bakehouse Regulation Act, 1863;
(*m*) Cleansing of Persons Act, 1897;
(*n*) Cremation Act, 1902; Cremation Regulations, 1903;
(*o*) Sale of Milk Regulations, 1901;

(*p*) Sale of Butter Regulations, 1902;
(*q*) Housing of the Working Classes Act, 1890;
(*r*) Notification of Births Act, 1907.

IV. IRELAND—
The Public Health (Ireland) Act, 1874; and others, embodying the principles of the foregoing Acts.

DUTIES OF A MEDICAL OFFICER OF HEALTH

Appointment

The appointment of Medical Officer of Health in England is laid down in section 189 of the Public Health Act of 1875, and section 191 enacts that no person shall be appointed to this office unless he is a legally qualified medical practitioner, and if appointed after 1st Jan. 1892 to a district of 50,000 inhabitants or over, unless he is the possessor of a registered degree or diploma in public health, hygiene, or sanitary science. The Local Government Board has certain powers respecting the appointment, duties, salary, and tenure of office of this official, where any portion of his salary is paid by moneys voted by Parliament. The medical officer to a union may be appointed medical officer of health to his rural sanitary district, although he does not possess any registered sanitary degree or diploma, and a medical officer of health may be appointed to act as a sanitary inspector, subject to the approval of the Board. By the Local Government Act, 1888, s. 18, the Local Government Board reserves the right to sanction the appointment of a person as medical officer or deputy medical officer of health who does not possess a public health qualification.

In Scotland the appointment is compulsory upon counties by section 52 of the Local Government (Scotland) Act, 1889; and section 54 enacts (1) that he shall be a registered medical practitioner, (2) that after 1st Jan. 1893, where the population of a county, district, or parish is 30,000 or upwards, he shall be registered as the holder of a qualification in sanitary science, public health, or state medicine, and (3) that he shall be removable from office only with the sanction of the Scottish Local Government Board. In burghs, under section 77 (1) of the Burgh Police Act, 1892, the medical officer must be in possession of a registered qualification in public health.

Duties

In England, the duties of this official are laid down in the Order of the Local Government Board, March 1891, and draft regulations suggested by the Local Government Board of Scotland are printed in the official instructions, forms, and recommendations to Local Authorities, 1903:[1] these are tabulated below:—

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[1] Page 177.

Regulations concerning Duties of Medical Officer of Health

England	Scotland
No.	No.
1. He shall inform himself as far as practicable respecting all influences affecting, or threatening to affect, injuriously the public health within his district.	3. In draft regulations is *verbatim* the same as No. 1 for England.
2. He shall inquire into and ascertain by such means as are at his disposal the causes, origin, and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.	4. Is same as No. 2 for England.
3. He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.	5. Is same as No. 3 for England.
4. He shall be prepared to advise the Sanitary Authority on all matters affecting the health of the district, and on all sanitary points involved in the action of the Sanitary Authority; and in cases requiring it, he shall certify for the guidance of the Sanitary Authority or of the justices, as to any matter in respect of which the certificate of a M. O. H. or a medical practitioner is required, as the basis or in aid of sanitary action.	6. Is same as No. 4 for England.
5. He shall advise the Sanitary Authority on any question relating to health involved in the framing and subsequent working of such bye-laws and regulations as they may have power to make, and as to the adoption by the Sanitary Authority of the Infectious Disease (Prevention) Act, 1890, or of any section or sections of such Act.	7. Is same as No. 5. for England up to and including the words "power to make."
6. On receiving information of the outbreak of any contagious, infectious, or epidemic disease	1. The M. O. H. shall perform all the duties lawfully imposed upon him by any bye-laws

of a dangerous character within the district, he shall visit the spot without delay and inquire into the causes and circumstances of such outbreak, and in case he is not satisfied that all due precautions are being taken, he shall advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and take such measures for the prevention of the disease as he is legally authorised to take under any statute in force in the district, or by any resolution of the Sanitary Authority.

7. Subject to the instructions of the Sanitary Authority, he shall direct or superintend the work of the inspector of nuisances in the way and to the extent that the Sanitary Authority shall approve, and on receiving information from the inspector of nuisances that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take such steps as he is legally authorised to take under any statute in force in the district, or by any resolution of the Sanitary Authority, as the circumstances may justify and require.

8. In any case in which it may appear to him to be necessary or advisable, or in which he shall be so directed by the Sanitary Authority, he shall himself inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk, and any other article to which the provisions of the Public Health Act, 1875, in this behalf shall apply, exposed for sale, or deposited for the purpose of sale, or of preparation for sale, and intended for the food of man, which is deemed to be diseased, or unsound, or

and regulations of the Local Authority; and he shall further observe and execute, so far as the circumstances of his district may require, the instructions of the Local Government Board.

2. The M. O. H. shall attend all meetings of the Local Authority and committees thereof, when so required.

8. When a certificate has been received from a medical practitioner or a notice from the head of a family in terms of section 3 (1) (*a*) and (*b*) of the Infectious Disease (Notification) Act, or otherwise the existence of a case of infectious disease has come to his knowledge, the M. O. H. shall instruct the sanitary inspector or other competent officer to make the necessary inquiries, and to take such measures as are necessary for preventing the spread of the disease.

9. It shall be the duty of the M. O. H. to enter or cause to be entered both the certificates and the notices in a book to be provided by the Local Authority, and to be called the Register of Notifications, which shall be kept in the office of the Local Authority for that purpose; he shall also tabulate and report to each ordinary meeting of the Local Authority the notifications received.

10. The M. O. H. shall also keep any other books or forms in connection with the Infectious Disease (Notification) Act, which the Local Government

unwholesome or unfit for the food of man; and if he finds that such animal or article is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall give such directions as may be necessary for causing the same to be dealt with by a justice according to the provisions of the statutes applicable to the case.

9. He shall perform all the duties imposed upon him by any bye-laws and regulations of the Sanitary Authority, duly confirmed where confirmation is legally required, in respect of any matter affecting the public health, and touching which they are authorised to frame bye-laws and regulations.

10. He shall inquire into any offensive process of trade carried on within the district, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

11. He shall attend at the office of the Sanitary Authority or at some other appointed place, at such stated times as they may direct.

12. He shall from time to time report in writing to the Sanitary Authority his proceedings, and the measures which may require to be adopted for the improvement or protection of the public health of the district. He shall in like manner report with respect to the sickness and mortality within the district, so far as he has been enabled to ascertain the same.

13. He shall keep a book or books, to be provided by the Sanitary Authority, in which he shall make an entry of his visits and notes of his observations and instructions thereon, and also the date and nature of applications made to him, the date and result of the action taken thereon, and of any action taken on previous reports, and shall produce such book or books, whenever required, to the Sanitary Authority.

Board may from time to time consider necessary.

11. Is the same as No. 6. for England.

12. When in his opinion any infectious disease threatens to become dangerous or epidemic within the district, the M. O. H. shall forthwith report the same to the Local Government Board and to the Local Authority, stating the extent of the outbreak, its supposed origin, and the measures adopted for the prevention of the spread of the disease, and for the isolation and treatment of those affected.

13. When the M. O. H. becomes aware that any infectious disease within the meaning of the Infectious Disease (Notification) Act exists at any dairy within the meaning of the Public Health (Scotland) Act, 1897, or in the household of any person registered under the Dairies, Cowsheds, and Milkshops Order, and that milk is supplied from such dairy or by such person without the district, he shall forthwith report the same to the Local Government Board, and to the Local Authority, specifying the name and address of such dairy or person and of the person to whom such milk is consigned, or the district within which it is supplied, and the measures adopted to prevent the spread of the disease.

14. He shall also make an annual report to the Sanitary Authority up to the end of December in each year comprising a summary of the action taken, or which he has advised the Sanitary Authority to take, during the year for preventing the spread of disease, and an account of the sanitary state of his district generally at the end of the year. The report shall also contain an account of the inquiries which he has made as to conditions injurious to health existing in his district and of the proceedings in which he has taken part or advised under any statute, so far as such proceedings relate to these conditions ; and also an account of the supervision exercised by him, or on his advice, for sanitary purposes, over places and houses that the Sanitary Authority have power to regulate, with the nature and results of any proceedings which may have been so required and taken in respect of the same during the year. It shall also record the action taken by him, or on his advice, during the year, in regard to offensive trades, to dairies, cowsheds and milkshops, and to factories and workshops. The report shall also contain tabular statements (on forms to be supplied by the Local Government Board, or to the like effect) of the sickness and mortality within the district, classified according to diseases, ages, and localities. Provided that if the medical officer of health shall cease to hold office before December 31, in any year, he shall make the like report for so much of the year as shall have expired when he ceases to hold office.

15. He shall give immediate information to the Local Government Board of any outbreak of dangerous epidemic disease within the district, and shall transmit to the Board a copy

14. The M. O. H. shall report to the Local Government Board and to the Local Authority every case of small-pox in the district as soon as it comes to his knowledge.

15. When the M. O. H. becomes aware that any infectious disease exists in any house in which children of school age reside, he shall cause intimation thereof to be made to the Clerk of the School Board and to the head-master of any school which such children or any of them may be attending.

16. Is the same as No. 18 of the English Order but substituting "Section 79 of the Public Health (Scotland) Act, 1897," in lieu of the section and Act therein named.

17. The M. O. H. on receiving information from any sanitary inspector that his intervention is required in connection with any nuisance, shall, as early as practicable, take such steps as he is legally authorised to take under any statute in force in the district, or by any resolution of the Local Authority, as the circumstances of the case may justify and require.

[*If the Local Authority desire that the M. O. H. shall superintend the work of the Sanitary Inspector, then No.* 17 *would read as No.* 7 *for England.*]

18. The M. O. H. shall in any case when required by the Local Authority, or when it appears to him to be necessary or advisable, exercise the powers conferred on him by Section 43

of each annual report and of any special report. He shall make a special report to the Board of the grounds of any advice he may give to the Sanitary Authority with a view to the closure of any school or schools, in pursuance of the Code of Regulations approved by the Education Department and for the time being in force.

16. At the same time that he gives intimation to the Board of the outbreak of infectious disease, or transmits to them a copy of his annual or any special report, he must give the like information, or transmit a copy of such report to the County Council of the county in which his district is situated.

17. In matters not specifically provided for in this order he shall observe and execute any instructions issued by the Local Government Board, and the lawful orders and directions of the Sanitary Authority applicable to his office.

18. Whenever the Local Government Board shall make regulations for all or any of the purposes specified in section 134 of the Public Health Act, 1875, and shall declare the regulations so made to be in force within the area comprising the whole or any part of the district, he shall observe such regulations so far as the same relate to or concern his office.

of the Public Health (Scotland) Act, 1897. In the case of any proceeding with regard to a living animal, unless he himself is a qualified veterinary surgeon, he shall call upon the veterinary surgeon approved by the Local Authority to accompany him.

19. Is the same as No. 10 for England.

20. The M. O. H. shall from time to time inspect any bakehouses which are workshops and are situated within his district, and he shall thereupon report to the Local Authority whether any steps are necessary to be taken for the purpose of enforcing, as respects such bakehouses, the provisions of the Factories and Workshops Acts.

21. Is the same as No. 12 for England.

22. The M. O. H. shall also from time to time make such special reports and returns as may be called for by the Local Authority or the Local Government Board.

23. Is the same as No. 12 for England.

24. The M. O. H. shall examine and report on all plans submitted to him by the Local Authority.

N. B.—*The Regulations for Scotland have no force or effect until they have been adopted by the Local Authority and have been approved by the Local Government Board.*

ANNUAL REPORTS BY MEDICAL OFFICERS OF HEALTH IN SCOTLAND

(Order of Board of date 18th January 1900)

In virtue of powers of section 15, *Public Health* (*Scotland*) *Act*, 1897.

FOR COUNTIES	FOR BURGHS
Report shall contain :—	Report shall contain :—
(*a*) A general account of the sanitary state of district, and of any measures which in his opinion should be adopted for its improvement.	(*a*) Same as for counties, substituting the word "burgh" for "district" in all cases.

(*b*) A statement of the general inquiries he has made during the year, and of any special inquiries as to sanitary matters.	(*b*) Same as for counties, substituting the word "burgh" for "district" in all cases.
(*c*) A general statement of any matters as to which he has given advice or granted certificates, including any action as to offensive trades and the sanitary condition of factories and workshops.	(*c*) Do. Do. Do.
(*d*) An account of his inspection of the bakehouses in the district, and of any proceedings taken with regard to them.	(*d*) Do. Do. Do.
(*e*) An account of the house-accommodation of the labouring classes in the district, and of any proceedings under the Housing of the Working Classes Acts, or otherwise.	(*e*) Do. Do. Do.
(*f*) An account of any action taken under the Rivers Pollution (Prevention) Acts.	(*f*) Do. Do. Do.
(*g*) An account of the available means of isolation of persons suffering from infectious disease, of houses of reception, and of apparatus for disinfection.	(*g*) An account of any proceedings under the Burgh Police Act, including the substance of his half-yearly reports on slaughter-houses (section 280).
(*h*) Observations on condition and adequacy of the apparatus provided for disinfection, and of the hospitals belonging to the Local Authority, or to which the Local Authority are entitled to send patients.	(*h*) Same as (*g*) for counties.
(*i*) A summary of the action taken to prevent the outbreak and spread of infectious disease.	(*i*) Same as (*h*) for counties.
(*j*) A statement as to the causes, origin, and distribution of diseases within the district, and the extent to which the same have depended on or been influenced by conditions capable of removal or mitigation.	(*j*) Same as (*i*) for counties.
(*k*) A tabular statement, in such form as the Local Government Board may from time to time direct, of the sickness and mortality with the district.	(*k*) Same as (*j*) for counties.
The Medical Officer of Health shall transmit a copy of report to the Local Government Board and to the Local Authority not later than the 31st	(*l*) Same as (*k*) for counties. The M. O. H. of a burgh shall transmit reports as for counties, and at same time.

March immediately following the year to which such report refers.

Where the County Medical Officer is M. O. H. for each of the districts in the county, the Board will hold the foregoing instructions to be complied with if the County Medical Officer furnishes a report for the whole county, provided that in such report each district is separately dealt with.

In Scotland, prior to the passing of the Public Health Act of 1897 and the Local Government Act of 1894, bye-laws regulating the duties of the Medical Officer of Health were issued by the Board of Supervision, of date 28th July 1873. These were, as far as they went, identical with those of the English Board. By section 15 of the Public Health Act of 1897, this duty of regulating the duties of medical officers and sanitary inspectors and their relations to each other is vested in Local Authorities, subject to the approval of the Board.

The duties of a Port Medical Officer of Health are essentially on the same lines as the foregoing, but different terms are employed by reason that ships, harbours, crews, etc., are being specially dealt with, and not houses and districts.

More specifically, these duties are as follow :—

1. The medical officer of health of a port shall inform himself, so far as is practicable, respecting all conditions which affect, or threaten to affect, injuriously the health of crews and other persons on board ships within his district.

2. He shall inquire into and ascertain, by such means as are at his disposal, the causes, origin, and distribution of diseases in any vessels within his district, and ascertain to what extent the same may have depended on conditions capable of removal or mitigation.

3. He shall, by inspection of the shipping in his district, keep himself informed of the conditions injurious, or likely to be injurious, to health which exist therein.

4. On receiving information of the arrival within his district of any ship having any infectious or epidemic disease of a dangerous character on board, or of the outbreak of any such disease on board ship within the district, he shall visit the vessel without delay, and inquire into the causes and circumstances of such outbreak, and advise the persons competent to act as to the measures which may appear to him to be required to be taken to prevent the extension of the disease, and, so far as he is lawfully authorised, to assist in the execution of the same.

5. He shall on receiving information from the inspector of nuisances that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a ship, as early as possible take such steps authorised by the Public Health Act, 1875, in that behalf as the circumstances may justify and require.

6. When any vessel within his district has had dangerous infectious disease on board, he shall give notice thereof to the medical officer of health of any port within the United Kingdom whither such vessel is about to proceed.

7. The medical officer of health, if he have reason to suspect that any ship coming or being within the jurisdiction or district of the Local Authority *whether examined by the officer of Customs or not*, is infected, shall, or, if he have reason to suspect that the ship has come from an infected place, may visit and examine such ship for the purpose of ascertaining whether such ship is infected,

and may make the like visit and examination in the case of any ship coming or being within the jurisdiction of the Local Authority which has come from an infected place. The master of any such ship shall permit the same to be visited and examined. The master of any such ship shall, on being required by the medical officer of health so to do, cause the ship to be brought to, and, if necessary, moored or anchored in some convenient place while the same shall be visited and examined, due regard being had to the safety of the ship, and to the convenience of navigation (Cholera, Yellow Fever, and Plague Order, 1898, Articles 8, 9, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22).

In Ireland, the position of the Medical Officer of Health is regulated by section 10 of the Public Health (Ireland) Act, 1874, which enacts that every medical officer of a dispensary district shall be a sanitary officer for such district or for such part thereof as he shall personally be in charge of, with such additional salary as the Sanitary Authority may determine subject to the approval of the Local Government Board. Every Sanitary Authority in Ireland must appoint (*a*) a consulting sanitary officer, (*b*) an *ex-officio* sanitary officer, who is the medical officer of a dispensary district, and (*c*) when thought necessary or advisable, a medical superintendent officer of health.

The duties of the Medical Officer of Health in Ireland are the following :—

1. He shall inquire into any matter which is brought under his notice by the sanitary sub-officer (or sanitary inspector).
2. He shall attend to and inquire into any matter brought under his notice by the executive sanitary officer, or clerk.
3. He shall report to the Sanitary Authority on any matter which should be brought under their notice, and he shall, from time to time, furnish statistical returns to the Local Government Board, of disease, etc.

Inspector of Nuisances. Sanitary Inspector. Sanitary Sub-Officer

The other important sanitary officer under the Public Health Acts is the inspector of nuisances, as he is called in England, or the sanitary inspector as he is called in Scotland, or the sanitary sub-officer as he is designated in Ireland.

In England, this official must be appointed by urban and rural sanitary authorities under sections 189 and 190 of the Public Health Act, 1875. He must be a "fit and proper person." By section 192 of the same Act the same person may act as surveyor and inspector of nuisances. Under the Local Government (England and Wales) Act, 1888, inspectors of nuisances are appointed for counties. In London, in terms of section 107 of the Public Health (London) Act, 1891, every Sanitary Authority must appoint a sufficient number of fit and proper persons, qualified and competent by knowledge or experience, to perform the duties of their office, as inspectors of nuisances.

In Scotland, by the Local Government (Scotland) Act, 1889, section 52, the Council of every county *shall* appoint a sanitary inspector or inspectors who shall not hold any other appointment or employment without the express written consent of the council, and by section 54 (3) no person shall, except with the express consent of the Board, be appointed to this office for a county unless he has been during the three consecutive years preceding his appointment the sanitary inspector of a Local Authority under the Public Health Acts, nor shall he be removable from office except with the sanction of the Board. Under the Public Health (Scotland) Act, 1897, section 15, Local Authorities *shall* appoint "a Sanitary Inspector or Inspectors" who "shall be also inspector or inspectors of common lodging-houses." He shall not be removable from office except by or with the sanction of the Local Government Board.

In terms of the Burgh Police (Scotland) Act, 1892, section 75, commissioners of a Burgh *shall* appoint a sanitary inspector, subject to the provisions of the Public Health Acts, whose duty it shall be to superintend and enforce the sanitary provisions of such Acts and this Act; and of section 76, the commissioners may, if they think fit, combine the offices of surveyor, inspector of cleansing, and sanitary inspector, or any two of them, in the same person.

In the Order of the Local Government Board for Ireland, Sanitary Authorities are directed to appoint sanitary sub-officers, in virtue of the Public Health (Ireland) Act, 1878.

Duties

The duties of this officer in England and Scotland respectively are set forth in the following tabular statement, those for England being laid down in the Order of the English Local Government Board of date March 1891, article 19, and those for Scotland in Draft Regulations suggested by the Scottish Local Government Board.

ENGLAND	SCOTLAND
1. The inspector of nuisances shall perform, either under the special directions of the Sanitary Authority, or (so far as authorised by the S. A.) under the directions of the medical officer of health, or in cases where no such directions are required without such directions, all the duties specially laid upon an I. N. by the Public Health Act, 1875, or by any other statute or statutes, or by the orders of the Local Government Board, so far as the same apply to his office.	1. The sanitary inspector shall perform all the duties specially imposed upon a sanitary inspector by any statute, or by any order issued by the Local Government Board, or by any bye-law or regulation lawfully made by the Local Authority. (If the L. A. desire that the sanitary inspector shall act under the superintendence of the M. O. H., the following words should be inserted at the beginning of No. 1:— "Subject to the general superintendence and directions of the Medical Officer of Health," and at the end there should be added: "He shall also, subject to the directions of the Local Authority, attend to the instructions of the Medical Officer of Health with respect to any measures which can be lawfully taken by a sanitary inspector.")
2. He shall attend all meetings of the S. A. when so required.	2. Same as No. 2 for England.
3. He shall, by inspection of his district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed in respect of the nuisances existing therein which require abatement.	3. Same as No. 3 for England.
4. On receiving notice of the existence of any nuisance within the district, or of the breach of any bye-laws or regulations made by the S. A. for the suppression of nuisances, he shall as early as practicable visit the spot	4. Same as No. 4 for England, but with the following addition:— "and if he finds that a nuisance under the Public Health Act exists, he shall intimate the same, within 24 hours thereafter, to the author of the nuisance,

and inquire into such alleged nuisances or breach of bye-laws or regulations.	and shall after a reasonable interval visit and inquire, and if he finds that the nuisance is not removed he shall report the matter in writing to the Local Authority, and act in accordance with such instructions as he may receive."
5. He shall report to the S. A. any noxious or offensive businesses, trades, or manufactories established within the district, and the breach or non-observance of any bye-laws or regulations made in respect of the same.	5. Whenever it appears to the sanitary inspector that the intervention of the M. O. H. is necessary in connection with any nuisance, he shall forthwith inform such officer thereof and shall, if requested, accompany him and assist him in his inspection of the locality.
6. He shall report to the S. A. any damage done to any works of water-supply, or other works belonging to them, and also any case of wilful or negligent waste of water supplied by them, or any fouling by gas, filth, or otherwise of water used for domestic purposes.	6. Same as No. 13 for England.
7. He shall from time to time, and forthwith upon complaint, visit and inspect the shops and places kept or used for the preparation or sale of butcher's meat, poultry, fish, fruit, vegetables, corn, bread, flour, milk or any other article to which the provisions of the P. H. A., 1875, in this behalf shall apply, and examine any animal, carcase, meat, etc., or other article aforesaid which may be therein, and in case any such article appear to him to be intended for the food of man, and to be unfit for such food, he shall cause the same to be seized, and take such other proceedings as may be necessary, in order to have the same dealt with by a justice, provided that in any case of doubt arising under this clause he shall report the matter to the M. O. H. with the view of obtaining his advice thereon.	7. The sanitary inspector shall keep the Register of Common Lodging-Houses ; he shall visit and inquire as to the condition of each common lodging-house within the district, at least *once every calendar month*, or oftener if required by the Local Authority, and enter in his journal a report of the result. He shall also report in writing to the Local Authority all unregistered common lodging-houses, as well as any violation of the statutory provisions or of the bye-laws of the Local Authority relating to common lodging-houses which may come to his knowledge, and act in accordance with such instructions as he may receive.
8. He shall, when and as directed by the S. A., procure and submit samples of food, drink, or drugs, suspected to be adulterated to be analysed by	8. The sanitary inspector shall keep the Register of Houses let in Lodgings, in accordance with the bye-laws made by the Local Authority, and shall

the analyst appointed under the Sale of Food and Drug Acts, and upon receiving a certificate stating that the articles of food, drink, or drugs are adulterated, cause a complaint to be made, and take other proceedings prescribed by the Acts.	otherwise act as in the instructions set down in No. 7.
9. He shall give immediate notice to the M. O. H. of the occurrence within the district of any contagious, infectious, or epidemic disease; and whenever it appears to him that the intervention of such officer is necessary in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall forthwith inform the M. O. H. thereof.	9. The sanitary inspector shall keep a register of offensive businesses lawfully established and carried on within the district, and shall report to the Local Authority any contravention of the bye-laws relating to such businesses; he shall also report when any offensive business is established or enlarged without the sanction of the L. A., or when any premises are used as a slaughter-house or knacker's yard without a licence.
10. He shall, subject to the directions of the S. A., attend to the instructions of the M. O. H. with respect to any measures which can lawfully be taken by an inspector of nuisances under the P. H. A., 1875, or under any statute or statutes, for preventing the spread of contagious, infectious, or epidemic disease of a dangerous character.	10. The sanitary inspector shall from time to time visit and inspect any water-closet, earth-closet, or privy, or similar convenience within the district used in common by the occupiers of two or more separate dwelling-houses, or by other persons, and shall report to the L. A. any offence under section 31 of the P. H. (Scotland) Act, 1897.
11. He shall enter from day to day in a book, provided by the S. A., particulars of his inspections, and of the action taken by him in the execution of his duties. He shall also keep a book or books, to be provided by the S. A., so arranged as to form, as far as possible, a continuous record of the sanitary condition of each of the premises in respect to which any action has been taken under the P. H. A., 1875, or under any other statute or statutes, and shall keep any other systematic records that the S. A. may require.	11. The sanitary inspector shall from time to time visit and inspect the workshops within the district, and shall report to the L. A. any contravention of the sanitary provisions of the Factories and Workshops Acts; on receipt by the L. A. of any notice from the inspector under the said Acts as to any sanitary defects, the sanitary inspector shall forthwith inquire into the same and report the result to the Local Authority.
12. He shall, at all reasonable times, when applied to by the M. O. H., produce to him his books, or any of them, and	12. The sanitary inspector shall from time to time visit the shops and places within the district with a view to the

render to him such information as he may be able to furnish with respect to any matter to which the duties of an inspector of nuisances relate.

13. He shall, if directed by the S. A. to do so, superintend and see to the due execution of all works which may be undertaken under their direction for the suppression or removal of nuisances within the district.

14. He shall, if directed by the S. A. to do so, act as officer of the said authority as Local Authority under the Diseases (Animals) Acts, and any orders or regulations made thereunder.

15. In matters not specifically provided for in this Order he shall observe and execute all the lawful orders and directions of the Sanitary Authority and the orders of the Local Government Board which may be hereafter issued, applicable to his office.

prevention of the sale of unsound food, and shall on receiving any complaint, or when required by the Local Authority, or when it appears to him to be necessary or advisable, exercise the powers conferred on him by section 43 of the P. H. (Scot.) Act, 1897. In any case of doubt he shall report the matter to the M. O. H. with the view of obtaining his advice thereon. In the case of any proceeding with regard to a living animal, he shall call upon the veterinary surgeon approved by the L. A. to accompany him.

13. Same as No. 8 for England.

14. The sanitary inspector shall keep the Register of Cowkeepers, Dairymen, and Purveyors of Milk, and shall from time to time, and once at least in every *three* months, visit all dairies, cowsheds, and milkshops within the district, and report the result to the L. A. He shall also inform forthwith the Local Authority of any infringement of the orders or regulations applicable to such premises.

(*If any other officer has been appointed by the L. A. to inspect the dairies, No.* 14 *will be omitted.*)

15. The sanitary inspector shall from time to time make such inquiries as may be necessary with a view to ascertaining whether the bye-laws made by the Local Authority are duly observed, and shall report to the Local Authority any violation of the bye-laws which may come to his knowledge.

16. In every case in which it shall be reported or otherwise become known to him that any person in a common lodging-

house, or in any tent, van, shed, or similar structure, is suffering from any infectious disease, the sanitary inspector shall forthwith report the same to the M. O. H. and act under his instructions.

17. The sanitary inspector shall, by the instructions of the M. O. H., remove or superintend the removal of any patient suffering from infectious disease, and shall carry out any process of disinfection or any other measures that may be required for preventing the spread of infectious disease. He shall also, as soon as possible, examine the sanitary arrangements of any house in which infectious disease has occurred, and report to the M. O. H.

18. The sanitary inspector shall, under the direction of the M. O. H., make inquiries into the circumstances of each case of infectious disease within the district as regards facilities for isolation, employment, school, water-supply, milk-supply and any other matters likely to assist the M. O. H. in carrying out his statutory duties; he shall also serve notices required by section 50 (2) and 53 (2) of the Public Health Act.

19. Same as No. 11 for England, but substituting "Public Health (Scotland) Act" for the Act therein named.

20. Same as No. 12 for England.

21. The sanitary inspector shall observe and execute all lawful orders and instructions of the Local Authority and the Local Government Board applicable to his office; and, if required, he shall attend upon the inspecting officer of the Local Government Board, and afford him such information and assistance as he may desire.

22. The sanitary inspector shall examine and report on all plans submitted to him by the Local Authority.

By the Order of 18th January 1900, the Local Government Board of Scotland calls upon the sanitary inspector to prepare annually a report with regard to his district for the year ending 31st December, such report to contain :

(*a*) A general account of the sanitary state of the district as regards water-supply, drainage, scavenging, nuisances, etc., together with any suggestions for its improvement.

(*b*) An account of his general inspections, and of any special inspections or inquiries, including the supervision of slaughter-houses, and other offensive trades, and the sanitary condition of schools and factories and workshops.

(*c*) An account of the condition of common lodging-houses.

(*d*) An account of the condition of the dairies, cowsheds, and milk-shops.

(*e*) An account of the condition of the burial grounds.

(*f*) A statement, in such form as the Local Government Board may from time to time direct, of his proceedings during the year.

He shall transmit a copy of the aforesaid report to the Local Government Board and to the Local Authority not later than the 31st March immediately following the year to which such report refers.

Relations of Medical Officer of Health to Sanitary Inspector and to Sanitary Authorities.—In England, by the Public Health Act, 1875, section 191, the Local Government Board has powers with regard to the qualification, appointment, duties, salary, and tenure of office of any medical officer of health, or other officer, part of whose salary is paid out of moneys voted by Parliament or the County Council ; and by the Local Government (England and Wales) Act, 1888, section 24 (3), with regard to counties under like conditions. The medical officer of health in England generally supervises and directs the operations of the inspector of nuisances.

In Scotland, by the Public Health (Scotland) Act, 1897, section 15, the Local Authority " shall, subject to the approval of the Local Government Board, regulate the duties of such medical officers and sanitary inspectors and their relations to each other, whether appointed before or subsequent to the commencement of this Act, and this notwithstanding anything contained in sections 75, 76 and 77 of the Burgh Police (Scotland)Act, 1892," . . . " and the names, addresses, and salaries of the said medical officers and sanitary inspectors shall be reported to the Board, immediately on such persons being appointed and such salaries fixed."

In Scotland, the regulations laid down by Local Authorities regarding the official relations of the medical officer of health and sanitary inspector are not uniform. Certain Local Authorities have constituted the medical officer head of the sanitary department ; on the other hand, other Local Authorities have constituted each of these officials head of his own department, and have regulated their relations to each other when statutory requirements bring the duties of the two officers into operation together.

In Ireland the duties of the medical officer of health and sanitary sub-officer are defined by the Irish Local Government Board.

In England, in terms of section 171 of the Public Health Act, 1875, and in Scotland, in terms of section 15 of the Public Health (Scotland) Act, 1897, the medical officer of health may, when authorised by the Local Authority, exercise any of the powers of the inspector of nuisances or of the sanitary nspector.

Deputy Officers.—In England, by section 191 of the Public Health Act, the Sanitary Authority, in case of illness or incapacity of the medical officer, may appoint and pay a deputy medical officer of health, subject to the approval of he Local Government Board. In Scotland, by section 15 of the Public Health Act, the medical officer of health and sanitary inspector shall, if required by the Local Authority, respectively name a duly qualified substitute for whom they hall be responsible, and, if the Local Authority shall approve of the nomination, uch substitutes shall have the same powers and duties as the medical officer or sanitary inspector, as the case may be, during the temporary illness or authorised absence of either of them, and the Local Authority may, with consent of the Local Government Board, withdraw their approval of such substitute, and may require the medical officer or sanitary inspector, as the case may be, to name for their approval some other duly qualified substitute.

In order to fulfil the duties expected of him, the Medical Officer of Health on appointment to a rural district ought, as a preliminary, to make himself acquainted with various points which may be classified under two main heads—viz.

I. Natural Conditions;
II. Artificial Conditions;

in respect of their action on the health of the inhabitants.

Under the former head, he should know the main facts regarding (*a*) the *Topography* of his district; such as its mean height above the sea-level, and its maximum and minimum heights; and the nature of the soil; (*b*) *Geology*, with relation to the quality and quantity of water-supplies from impounded reservoirs, natural collections of waters and wells; existence of sand or gravel tracts for interment purposes; and the like; (*c*) *Meteorology*, with respect to force, direction and prevalence of winds, mean rainfall, barometric pressure, etc.; (*d*) *Existing provisions for Water-supply*, with respect to sources, having regard to possible impurity in well-supplies, or, if from streams, of the likelihood of contamination in their course; its quality and quantity, with reference to improvement or extension of supplies; (*e*) *Drainage and Sewerage*; (*f*) *Habits of the Population* with respect to cleanliness or the opposite, overcrowding, etc.; (*g*) *Mode of Disposal of Night Soil and House Refuse.* In view of the milk traffic from rural districts to urban, it will be part of his work to discover the source of water-supplies of dairy farms, from the point of view of possible contamination.

The second group of conditions are mainly found in urban or populous districts, due to the congregation of Man in large centres, and it comprises among others the following subjects—viz.

(*a*) The houses in which the population lives;
(*b*) The water-supply;
(*c*) Disposal of sewage, and house-drainage arrangements;
(*d*) Effects of trade processes, offensive trades, factories, etc., upon health.

In order that he may comply with the duty of providing the requisite returns of the mortality of his district, it is absolutely necessary that the medical officer should have thorough knowledge of the statistics of his district, which facts he may obtain from the census returns and from the registrars of his district.

According to clause 14 of the Order of the English Local Government Board, the Medical Officer of Health shall make an annual report to the Sanitary Authority up to the end of December in each year, which shall contain a summary of the action taken, or advised by him to be taken, during the year. The clause details the matters to be dealt with in such report. While, of course, reports by Medical Officers of Health are bound to differ in respect of the order in which the subjects contained are treated, the following order seems to suggest itself as one worthy to be followed :—

I. General Statistics ; including—
- (*a*) Population, estimated and actual ;
- (*b*) Population, density of, in districts or wards ;
- (*c*) Marriage-rates ;
- (*d*) Birth-rates ;
- (*e*) Death-rates, general, for area, districts, and parts of districts ; death-rates for age-groups, and for sexes ; infantile mortality ; pulmonary diseases rates ; zymotic mortality ; phthisis death-rates ;
- (*f*) Infectious Diseases—number of notifications from whole area and districts ; distribution of diseases, as shown by geographical incidence of notifications ; notifications of different diseases ;
  - Small-pox and vaccination—vaccination returns ;
  - Measles, in relation to schools ;
  - Scarlet-fever — sickness-rate, death-rate, fatality-rate — preventive measures—recurrent or return cases ;
  - Diphtheria—bacteriological diagnosis, use of anti-toxin ;
  - Whooping Cough—age, distribution, etc. ;
  - Enteric Fever—source of outbreak, etc. ;
  - Diarrhœa and Enteritis—age and sex ; incidence ; relation to infantile mortality ;
  - Influenza ;
  - Puerperal Fever ;
- (*g*) Admissions to Infectious Diseases Hospital—results, deaths, recoveries, etc. ;
- (*h*) Disinfection—houses, clothing, etc. ;
- (*i*) Tubercular Diseases—notifications, treatment, etc. ;
- (*j*) Other Causes of Death—such as syphilis, alcoholism, cancer, premature birth, bronchitis, pneumonia, accidental suffocation, including overlying of infants, violence, etc. ;
- (*k*) Diseases of Animals communicable to man ;
- (*l*) Tuberculosis and the milk-supply ;

II. Operations under the Midwives Act of 1902 ;

III. Housing of the Working Classes ;
- (*m*) Common lodging-houses ;
- (*n*) Houses sub-let in lodgings ;

IV. Cows and Cowsheds, Milkshops, and Disease ;

V. Canal Boats, tents, vans, etc. ;

VI. Inspection of Foods—operations under Food and Drugs Acts, etc. ; Slaughter-houses ;

VII. Factories and Workshops ;

VIII. Abatement of Nuisances, etc., Offensive Trades ;

IX. Statistical Tables.

In rural districts, attention would, in addition to the foregoing, be paid to (*a*) water-supplies, and (*b*) prevention of river pollution, to sewerage and drainage, removal and disposal of house refuse, disposal and purification of sewage, etc.

By the revised Instructions of the Scottish Local Government Board, that Board requires that the Annual Report by the Medical Officer of Health shall contain:

(*a*) A general account of influences and conditions injurious or dangerous to the health of the district, and of the measures that in the opinion of the medical officer should be adopted for their prevention or improvement;

(*b*) A statement of the general inquiries the medical officer has made during the year, and of any special inquiries as to sanitary matters;

(*c*) A general statement of any matters as to which the medical officer has given advice or granted certificates, including any action as to offensive trades;

(*d*) A specific account of the administration of the Factory and Workshop Act, 1901, in workshops and work-places, in terms of section 132 of that Act;

(*e*) An account of the house-accommodation of the labouring classes in the district, and of any proceedings under the Housing of the Working Classes Acts, or otherwise;

(*f*) An account of any action taken under the Rivers Pollution (Prevention) Acts;

(*g*) An account of the hospital accommodation available for persons suffering from infectious disease (including the means provided for the conveyance of such persons), and of the houses of reception, with observations on the furnishing, maintenance, administration and adequacy of such accommodation, etc.

Such a classification of subjects to be considered leaves much to the individual officer as to the scope of their treatment; and so while some reports are relatively meagre, others are full and illuminative.

CHAPTER II

VITAL STATISTICS AND STATISTICAL RETURNS

One of the important duties of the Medical Officer of Health is that which deals with disease in its statistical aspects. Without an accurate knowledge of the population of his district, therefore, returns made by him will lose their value because of their inaccuracy. By means of previous census returns, a knowledge may be gained of the increase or decrease of population within the district, but for instituting tabular returns, such as birth-rates, death-rates, etc., it is requisite that the population of the year under which they are given should be known either absolutely or by computation.

The Public Health (Scotland) Act, 1897, s. 15, enacts that "The registrar of births, deaths, and marriages in each registration district shall furnish to the Local Authority such periodical returns of births and deaths as may be required of him and approved by the Local Government Board, and for each death included in such return and for each return of births he shall be paid by the L. A. the sum of twopence, and the L. A. shall provide the forms on which such returns are to be made, and shall pay for their transmission by letter post."[1]

Population.—Since the year 1801, a decennial return has been made of the population of these islands, but it was not till the return of 1881 that age and sex distribution was given. The first census of the whole British Empire was taken in 1871. At census periods, therefore, is the actual population only definitely and accurately known; between these periods the population is estimated.

The Census.—The periodic enumeration of the people is now an institution in every civilised country, Russia having only instituted, however, the first census of its empire in 1897. The time of the year at which it is taken varies in different countries. At the last census (1901) the Netherlands led the way on the last day of December. The machinery for taking the census also varies in different countries. In Germany, the census is ordered by a decree of the Imperial Federal Council, which determines the questions to be asked and the general rules and principles to be followed; in France, the Minister of the Interior controls the machinery; the mayor of a commune or municipality, appointing the supervisors and enumerators, acts under the direction of the prefect of the department, and the prefect is subject to the control of the minister; in Italy, the enumeration is taken under the direction of the Minister of Agriculture, Commerce, and Manufactures; and in the United States, by the Census Officer at Washington.

In Great Britain, the Registrar-General of each country, acting under the Local Government Board and Secretary for Scotland respectively, is charged with the duty, the permanent organisation for registration of births, etc., being utilised in supervising the enumerators, who are appointed in each locality for that purpose. In Ireland, the constabulary district is the unit enumeration district, and the Royal Irish Constabulary and the Dublin Metropolitan Police form the enumerating staff.

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[1] For forms approved by Local Government Board, *vide* "Book of Instructions, Forms, etc.," p. 196.

Since the year 1801, a decennial census only has been taken in this country, but in other countries it is quinquennial. The ancient Roman census, for example, was taken every five years; and the quinquennial period has been in operation in Sweden since 1805, in France since 1835, in Germany since 1866, and in Finland since 1875. The system also prevails in half of the American States, in New Zealand, Queensland, and in Manitoba, and other parts of north-west Canada.

Attempts have been made in this country from time to time to induce the Legislature to institute a quinquennial, instead of a decennial, period, and the agitation in 1888 became so acute that in that year the Government appointed a Treasury Committee to inquire into the whole subject of the census. After taking evidence, the committee reported[1] in 1890 in favour of the institution of a quinquennial census and the establishment of a permanent staff and office for census purposes. No effect has as yet been given to the recommendations of the committee, the difficulty in the way apparently being the procuring of a larger grant from the Treasury for census purposes.

The scope or range of information asked for in the census also varies in different countries. Up till 1901, only five countries in the world, in addition to the United States—viz. Germany, France, Denmark, Belgium, and Hungary—had taken an industrial census. Even these varied in their scope. Germany, for example, while asking for detailed information respecting kinds of manufactories, their motive power and their machinery, paid but scant attention to the personal condition of those employed; Denmark asked for details as to wages paid to workers, classified according to kind of work, but left out machinery; France and Hungary mainly centred their attention on collecting information relating to the occupation and personal condition of employers and employed; while that of Belgium, in her census of 1896, is, perhaps, the most detailed and comprehensive of all European industrial enumerations in respect of range of informative details. The census of the United States of America embraces extended inquiries regarding population, mortality, manufactures, and agriculture.

The census of Great Britain has mainly concerned itself, if we overlook minor differences in the earlier enumerations, with the personal conditions of individuals.

The census machinery in this country is started by the introduction of a Census (Great Britain) Bill and a Census (Ireland) Bill into Parliament, wherein are determined the day upon which the census is to be taken, the central authorities for taking the census, the provisions for payment of costs, the enumeration districts, preparations, filling, collection, correction and copying of schedules, the enumeration of persons in public and charitable institutions and returns of persons travelling, or on shipboard, or not in houses on night of census, the making of abstracts of the returns and supplying further abstracts to Local Authorities, and penalties for offences.

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[1] Blue book C6071, 1890.

In the bill introduced in 1910 for the 1911 census, the day fixed was Sunday the 2nd day of April in that year. In former years the day fixed was always the last day of the first quarter of the year.

For census purposes every registration sub-district is divided into enumeration districts, and an enumerator appointed for each such district, poor-law overseers and relieving officers to act as enumerators if so called upon by the Local Government Board. The census schedules to be prepared by or under the direction of the Local Government Board for England, or the Secretary for Scotland, shall contain the following particulars to be filled up by or on behalf of occupiers of houses—viz. (1) name, (2) sex, (3) age, (4) profession or occupation, (5) condition as to marriage, (6) relation to head of family, (7) birthplace, (8) and (where person was born abroad) nationality of person, (9) whether any person was blind, or deaf and dumb, or imbecile or lunatic, (10) where occupier occupies less than five rooms, the number of rooms occupied; and (11), in the case of Wales or county of Monmouth, whether any person, three years of age and upwards, speaks English only, or Welsh only, or both English and Welsh. With reference to Scotland, under this head, the return to be made was whether the person speaks English only, or Gaelic only, or both English and Gaelic.

During the week ending the day before the census day, each enumerator was to leave at every dwelling-house within his district one or more of the schedules, and was to collect the filled schedules on the day following the census day. Every occupier was to fill the schedule with above particulars of each person who resided in the house, tenement, or apartment occupied by him during the night which ushered in the census day. The term "dwelling-house" was to include every building or tenement of which the whole or part was used for human habitation; and where a dwelling-house was let or sub-let in different tenements or apartments and occupied by different persons or families, a separate schedule was to be left for each such occupier. In the application of the Act to Scotland, the particulars to be furnished by the enumerators with respect to each dwelling-house were (*a*) the number of rooms, including kitchen (if any) as a room, having a window, not being a window with a borrowed light. In the case of a person who is travelling or is at work on the night of the census day, and who returns to the house on the morning of the following day, such person is to be treated in the schedule as a person who abode in such house on the night of the census day.

Every enumerator was to collect the schedules which he left, see that each schedule was completely filled, aid in filling up or correcting the same, copy the same when completed and corrected, and furnish a return, according to the best information he is able to obtain, of all persons within his district on the night of the census day but who are not included in the schedules collected by him. He was also to furnish prescribed particulars as to whether or not houses were occupied or empty, and as to the county, borough, parish or other area for electoral or administrative purposes, and the ecclesiastical parish or district, in which each house is situated. The enumeration of inmates in public and charitable institutions was to be made by the governor, master, or chief resident officer, conform to instructions by authority of the Local Government Board. The Registrar-General was to obtain returns of persons travelling, or on shipboard, or not abiding in houses on the night of the census, and to include these returns in the abstracts to be made. He was to prepare, subject to the approval of the Local Government Board, (1) a preliminary abstract, and (2) a detailed abstract of the census returns, the former to be printed and laid before both Houses of Parliament within five months next after the census day, or, if Parliament was not then sitting, within fourteen days of the session next ensuing. He was empowered, if he thought fit, at the request and cost of a council of any county, borough or urban district, to cause abstracts to be prepared containing statistical information with respect to such county, borough or district, which could be supplied from the returns but was not supplied in the census report, and which, in his opinion, the council may reasonably require. Penalties were enacted for wilful default in the performance of duty of anyone employed under the act, wilful refusal to fill up a schedule by any occupier, giving false information or false answers, or for giving information, without lawful authority, from the census returns.

It would be impossible here to deal with the results of a census in detail, but there are certain outstanding interesting facts connected with the 1901 census of the British Empire which may be briefly noticed. Between the census of 1861 and that of 1901—a period of forty years—the Empire had extended from 8½ millions to nearly 12 millions of square miles, the area of the European portion of the Empire being only 126,000 square miles; the population during the same period had increased from close on 259 millions to 400 millions, of which 41½ millions reside within the United Kingdom. This increase of population was due to two causes—viz. (*a*) increase of area or extension of territory, and (*b*) natural increase or migration from one part of the Empire to another or from another state into the Empire. In the decade 1891–1901, the population of the United Kingdom increased 9·9 per cent.; of Canada, 11·1 per cent.; of Australia, 18·6 per cent.; of Natal, 54·2 per cent.; and of the Cape of Good Hope, 57·8 per cent.; while that of India, doubtless owing to famines and plagues, actually diminished about 5·5 per cent.

At the census of 1901, the density of population in the United Kingdom was 324 persons per square mile. The proportion of the male population engaged in agricultural pursuits was found to be, in Ireland, 21 per cent.; in Scotland, 7·8 per cent.; and in England and Wales, 6·8 per cent.; and the proportions of both sexes employed in domestic service to be, in England and Wales 12·5 per cent. of the total population, in Ireland, 9·6 per cent.; and in Scotland, 8·8 per cent.

INCIDENCE AND MOVEMENTS OF POPULATION

In the census of 1901 it was shown that 77 per cent. of the total population of England and Wales lived in towns, of Scotland, 70 per cent., and of Ireland, 31 per cent. The most noteworthy phenomenon in relation to the incidence of population in Great Britain between 1871 and the present time is the migration of rural dwellers to the towns. According to the figures of the Registrar-General for Scotland, the rural population has decreased from 1,021,321 in 1871 to 885,800 in 1901. The rate of rural depopulation since 1871, divided into decades, was in 1871–1881, 3·96 per cent.; in 1881–1891, 5·33 per cent.; and in 1891–1902, 4·6 per cent. The rate of increase of town population during the same decades was respectively 18·2 per cent., 14·06 per cent., and 18·58 per cent.; and the proportion of the population of Scotland inhabiting rural districts fell from 30·4 per cent. in 1871 to 19·8 per cent. in 1901. This fact is of serious import, not less from the economic than from the hygienic point of view. The rural dweller would seem to be attracted to the town by the prospect of better wages, of employment for families of growing lads and girls, larger scope and choice of employments, and by the glamour of movements of crowds and the more lively conditions of city life generally—anticipations, however, not always realised. Emigration, too, plays no unimportant part in the movement of population in a crowded country like Great Britain, especially during continued spells of trade depression, and, for like reasons, there is migration from town to town in search of employment, and, also, to newly established centres of industry. There are thus two movements of population: one within a country, and a second from one country to another, either within the same empire or to a foreign state.

Estimations of populations are liable to inaccuracy, nevertheless they must be calculated for statistical purposes. *The estimate for any intercensal year is made on the assumption that the rate of increase or decrease in a given population, as ascertained by the two previous census returns, continues uniformly the same.* This assumption may be near or very far from the mark. For example, the death-rate of Liverpool, based on the population of the census of 1881, was shown to be 26·7 per thousand; and on the assumption that the population had gone on increasing in the same ratio which obtained between the census figure of 1871 and that of 1881, the population in 1890 was accordingly estimated to be relatively greater and the death-rate worked out at 23·6 per thousand; but when the census figure of the population for 1891 was announced, it was seen that the population instead of increasing had decreased, and that the death-rate figure of 23·6 per 1000 returned for 1890 should have been 27·8 per 1000. The population of Glasgow was estimated by the Registrar-General to be, in June 1900, 743,969, but the census of the year 1901 showed the figure to be 760,406. Many other instances might be given where, on the other hand, the population was underestimated. However, the above method is that employed by the Registrars-General, and, therefore, demands some further explanation. Given, therefore, the population of a given district at a fixed date, to find the population after a given number of years thereafter. The main normal factor in the increase of any population is the excess of annual births over the annual deaths—not reckoning, for the moment, the elements of immigration and emigration.

The method of the Registrar-General of estimating intercensal populations may be likened to a sum of money invested at compound interest. In the first year of investment, interest accrues to the principal or capital sum invested; in the second year, the capital now becomes the original capital sum plus the interest accruing at the end of the first year; and so on, in each successive year.

Let us suppose that this rate of increase per unit is represented by r, then at the end of the first year the increase will be represented by $1+r$; it will equal—

At the end of the second year, $(1+r)^2$
,, ,, third ,, $(1+r)^3$
,, ,, fourth ,, $(1+r)^4$
,, ,, fifth ,, $(1+r)^5$
and so on till the tenth, $(1+r)^{10}$
or the *nth* year $(1+r)^n$.

Let $R=1+r$.
Let $P=$ the population of one census.
Let $P^1=$ the population of the next following census.

Then if $r=$annual increase per unit, and $R=1+r=$annual increment of each unit per annum, then—

$P(1+r)^n=PR^n=P^1$.
But $n=10$ in this case.
$\therefore PR^{10}=P^1$. Hence the logarithm of $P+10\log. R=\log. P^1$.
And $10\log. R=\log. P^1-\log. P$.
$\therefore \log. R=\frac{1}{10}(\log. P^1-\log. P)$.

We quote the following working example from Newsholme [1]—

If the census population of a town is 32,000 in 1871, and 36,000 in 1881, what is the mean population in 1885?

$1871=P=32,000$
$1881=P^1=36,000$
Log. of $P^1=\log.$ of $36,000=4\cdot556303$
Log. of $P=\log.$ of $32,000=4\cdot505150$
$\therefore$ Log. $P^1-\log. P=0\cdot051153$
And $\frac{1}{10}(\log. P^1-\log. P)=0\cdot051153\div10=0\cdot005115=\log. R=\log. 1+r$.
$\therefore R=1+r=1\cdot10118$.
$n=1885\frac{1}{2}-1881\frac{1}{4}=4\frac{1}{4}$ years, since the mean population of any year is that of the middle of the year, and since the census is taken at the end of the first quarter.

In the above problem, therefore—

$P^1=PR^n$, where $P=36,000$,
,, $R=1\cdot0118$,
,, $n=4\frac{1}{4}$ years.

$\therefore P^1=$Pop. required$=36,000\times(1\cdot0118)^{\frac{17}{4}}$.

And $\log. P^1=\log. 36,000+\frac{17}{4}\log. 1\cdot0118$.

But log. of $1\cdot0118=0\cdot005115$.

$\therefore \frac{17}{4}\log. 1\cdot0118=0\cdot021739$

Log. of $36,000=4\cdot556303$

Therefore by addition, $\log. P^1=4\cdot578042$

Log. $4\cdot578042=37,848=$the required population of 1885.

From the foregoing, it will be seen that the increase of population is calculated as a geometric increase, and not as an arithmetic increase. This will be more apparent if we work out the same problem on the simple arithmetic increase—

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[1] "Vital Statistics," 1st ed., p. 6.

Population of 1881 = 36,000
,, ,, 1871 = 32,000
Total decennial increase = 4,000
Annual increase = 4,000 ÷ 10 = 400.

$$400 \times \frac{17}{4} + 36{,}000 = 37{,}700 \text{ =the required population of 1885.}$$

There are other methods, however, of ascertaining an intercensal population :—

A. By adding to or subtracting from the product of the difference between the total births and the total deaths since the last census return, the balance of immigrants and emigrants.

This is likely to be inaccurate, because there is no means of knowing, at least in this country, the number of persons who enter or leave a given area within a given time.

B. By ascertaining the number of inhabited houses within the area, and multiplying the figure found by the average number of persons per house as ascertained from the last census.

This method is fairly accurate as a working basis in population where the inhabited houses are reckoned annually for assessment purposes, but, as has been pointed out, it is liable to be fallacious where in new suburbs large numbers of houses are rapidly run up, and where these are occupied by newly-married persons.

Indeed it may be said that all the methods of estimating intercensal populations are liable to error for various reasons, and the approximate truth can only be arrived at by the use of all the available means.

The subject of estimates of population has been a vexed question for a considerable time, arising mainly out of the discrepancies which have been found to exist between calculated intercensal populations and the actual census figures when obtained. An important article contributed by Waters, chief clerk to the English General Register Office, will be found on this subject in the Supplement to the Sixty-Fifth Annual Report of the Registrar-General for England.[1] From it we extract the following particulars.

He points out that, in the absence of complete records of emigration from and immigration into England and Wales, the best available data for estimates of population in 1891–1900 are the census enumerations of 1891 and 1901 and the intermediate census of London in 1896, that the arithmetical means of the populations of 1891 and 1901 are the most readily calculated figures which could be used as estimates, leaving London out of count for the moment, and these figures would be accurate if the censuses were taken at the beginning of January instead of at the end of March or beginning of April, and if also the changes in the numbers of population during the decennium could be assumed to take place by arithmetical progression. It is more reasonable to assume, however, that population increases by geometrical progression than by arithmetical progression. Apart from the labour involved in the computation of estimates of population for all districts and counties on the assumption of geometrical increase, there is an objection to this assumption in that its results are not consistent; if, for example, it is true for districts, it is not true for the counties which are composed of these districts, and if true for districts or for counties, it is not true for the country as a whole. He adduces the following example :—" A district had a population of 10,000 at one census, and of 11,025 at the next census; on the assumption of geometrical increase its population midway between the two censuses was 10,500. Another district had populations of 10,000 and 22,500 at the two censuses; on the same assumption, its population midway between the censuses was 15,000. The two districts together increased from 20,000 to 33,525 in the intercensal period; and the aggregate of the estimates for the two districts in the middle of the period is 25,500. But if the assumption of geometrical increase be applied to the two districts together instead of to each district separately, the estimate for the middle of the period will not be 25,500 but 25,894. If, then, the method of geometrical increase be used at all, and if consistent results be required, the choice lies between two alternative ways of applying it. Either it can be applied to each separate district in the country, and the aggregate of the estimates for the districts can then be taken as the estimate for the whole country, or it can be applied to the country as a whole, and the resulting estimate divided in some manner among the districts." The assumption of a regular change in the population of an entire country involves less risk of error than the same assumption respecting portions of population, because the former is independent of the factor of migration between one populous place and another within the country. It was concluded, therefore, as involving least error, that the estimates of population in England and Wales in 1891–1900 could be best based on the assumption that the population of the country as a whole increased by geometrical progression. The problem became, thereafter, how to calculate the estimates for the several districts as portions of the total estimate. Reverting to the example already given, and taking the total populations of 20,000 and 33,525 at two successive censuses as increasing by geometrical progression, the population in the middle of the period would be 25,894.

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[1] P. cxvii.

The relations of the two districts to the total are as follows :—

	First Census		Second Census	
	Population	Proportion of Total	Population	Proportion of Total
District A . .	10,000	·5	11,025	·32886
District B . .	10,000	·5	22,500	·67114
Total .	20,000	1·0	33,525	1·00000

District A changed from ·5 to ·32886 of the total—that is to say, the proportion decreased by ·17114. If the decrease be supposed to have occurred by arithmetical progression, the proportion at middle of the period was $\cdot 5 - \frac{\cdot 17114}{2} = \cdot 41443$. In like manner, the population of District B at the same time of the period was ·58557 of the total.

The resulting estimates are as follows :—

	Population at Middle of Period	
	Proportion of Total	Number
District A . . .	·41443	10,731
District B . . .	·58557	15,163
Total . . .	1·00000	25,894

The application of this method, he further points out, is not limited to two districts or to the population between the censuses ; whatever the number of districts into which the total is divided, and whatever the interval, if the *proportions* be calculated by arithmetical progression their sum will always be unity, and the estimates for districts will always agree with the estimate for the total. He had already shown[1] (1) that the population of the whole changes by geometrical progression, and (2) that the proportion of each district to the whole changes by arithmetical progression. The short method of obtaining the same results as exemplified in the preceding tables is as follows :—The two factors for the population midway between the censuses are given by the following formulæ—viz.

$\frac{\sqrt{r}}{2}$ and $\frac{1}{\sqrt{r}}$: where r is the intercensal rate of increase of the total population. In the example given r is $\frac{33525}{20000} = 1{\cdot}67625$, and $\sqrt{\frac{1{,}67625}{2}} = {\cdot}64735$, and $\frac{1}{\sqrt{1{\cdot}67625}} = {\cdot}38619$.

Whatever, then, the number of districts, the mid-census population of each district is calculated by multiplying its population at the first census by ·64735, and its population at the second census by ·38619. The calculation works out as follows :—

		Census Population	Factors for Mid-Census Estimates	Census Population Multiplied by Factors	Mid-Census Estimates
District A	First Census	10,000	·64735	6473·5	10,731·2
	Second ,,	11,025	·38619	4257·7	
District B	First Census	10,000	·64735	6473·5	15,162·8
	Second ,,	22,500	·38619	8689·3	

and the estimates are the same as before.

These two factors having once been calculated, the estimates of population for all districts can be obtained by a simple process directly from their census populations.

This method of factors can be extended over any number of periods.

Having ascertained the total population, the next step is to sort it out into ages. This is called the *Age-Distribution* of a population, and has been given by the Registrar-General since the census return for 1881. For statistical purposes, it is supposed to remain constant for all ages from one census period to the next. It is important that the age-distribution should be ascertained, since the death-rates of infancy and old age are considerably higher than those of intermediate ages, and because populations differ as to the numbers of persons living at these ages. It may be taken as a general fact that rural populations contain a larger proportion of persons at the extremes of life than town or urban populations.

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[1] *Jour. Roy. Stat. Soc.*, June, 1901.

Sex-Distribution.—Owing to the lower death-rates which prevail in the female sex, except between the ages of 10 and 15, the existence of a large proportion of females in any population tends to lower the general death-rate. This is true of suburban, factory - town, and watering-place populations, where a large number of female domestic-servants and factory-hands compose the population.

Density of a Population.—The denser the population in a given area the higher will be the general death-rate, under ordinary circumstances. This has been abundantly proved from the experience of populous places.

This is seen, for example, in the death-rates per 1000 of the following Glasgow Districts for 1899 :—

TABLE I

District	Number of Persons per Acre	Death-rate per Thousand
Kelvinside	9	6·47
Hillhead	12	9·66
Blythswood . . .	107	15·60
High Street (West Side) .	242	26·66
Cowcaddens . . .	280	32·66

The average density of any given population is arrived at by dividing the total number of the inhabitants by the area covered by their habitations. Thus the density is reckoned as so many persons per acre, or square mile, or by any other unit of space. The actual density is obtained by ascertaining the precise number of inhabitants living within a certain defined and measured area. Hence the average density may be no true guide to the actual densities in a given population, since the most densely and most sparsely populated districts are averaged together, as are also the most open and most crowded spaces. In like manner the number of rooms in a house has an effect on the health of its population ; generally speaking, the smallest houses, which give the highest death-rates, are those which are occupied by persons whose struggle for existence is the hardest.

Vicious habits of certain classes of population produce fruits in high infantile mortality, shortened lives generally, and in high death-rates. This might be demonstrated in many ways, but the following table of the actual conditions which existed in one of the worst districts of Glasgow will suffice to make every point clear. In this district

50 per cent. of the houses are "ticketed"—that is, they are liable to be inspected at any hour of night or day for the existence of overcrowding. The population largely consisted of the immoral, criminal, and lazy classes.

TABLE II

EFFECTS OF UNCLEANLINESS AND VICIOUS HABITS ON HEALTH OF POPULATION[1]

Glasgow District

	Worst	Best	Average of City
Birth-rate per 1000 of population	30·49	26·14	34·92
Death-rate ,, ,,	32·45	13·89	20·91
Uncertified deaths . . .	18·5%	3%	5·7%
Infantile death-rate (per 1000 born)	239	88	133
Illegitimacy	25%	3%	8%
Premature births (per 100 children born)	41	12	17·5
Inferior houses (ticketed) . .	51%	1·4%	18%
Providence (as shown by insurance in Friendly Societies) .	40%	70%	56%
Demands on sanitary staff (per 100 of population) . . .	231%	55	84%
Born on rates and charity—			
Hospital	10%	. .	3%
Out-door	45	. .	22%
Vaccinated by rates and charity	50%		25%
Treated in sickness by—		. .	
Rates	25·4%	. .	10·6%
Charity	4·3%	. .	4·9%
Spent in food	50%	. .	Unknown
Spent in drink	50%	. .	,,

The contrast will be shown even better by comparing this very bad district with another district in Glasgow in which the density of population is greater, where the percentage of one- and two-roomed houses is identical, but which is inhabited mainly by the industrious artisan classes.

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[1] "The Cleansing Department is largely occupied in sweeping up and removing filth which is thrown over the windows and deposited about the courts. There are men employed doing nothing else but going round these courts and closes every few hours throughout the day with brush and hose and water-pail, and yet they are never clean." This district "furnishes the greater part of the work of the Central Police Court." *Vide* paper on "Sanitation and Social Economics," by the late Dr J. B. Russell, Medical Officer of Health, Glasgow, *Transactions of Phil. Soc. of Glasgow*, vol. xxi.

TABLE III
(1881)

	St Rollox District IV	Bridgegate and Wynds District XIV
Population . . .	14,211	7775
Density per acre . .	316 persons	222
Total births . . .	654	299
Total deaths . . .	310	295
Birth-rate . . .	46 per 1000	38·5
Death-rate . . .	21·8 ,,	37·9
Number of deaths under five	132	131
Percentage of deaths under five to total deaths .	43	44

Within the last few years, however, this unhealthy district (XIV.) has been completely changed for the better; old houses have been pulled down by streets; new and wider streets have been formed; and, generally, by the substitution of new houses and free air-spaces, its high mortality has disappeared.

But even density of population and the operation of other adverse factors are not always productive of the highest death-rate in a mixed population. If we take the death-rates per million from phthisis and acute pulmonary diseases as our test, density of population alone does not appear to be the principal factor. For example: in the St Rollox district of Glasgow, where the density has now risen to 368 persons per acre, and in that of Cowcaddens, where it is only 280 per acre, the number of deaths per million from these diseases in the former was 4957, whereas in the latter it was 11,548, notwithstanding the fact that in the centre of the former is one of the largest chemical works in the world, and many large engineering and other works. Moreover in 1898 the general death-rate from all causes was in the former 19, and in the latter 32 per thousand per annum.

That mere density of population is not the lethal factor in a picked population which it is in a mixed and vicious population is shown by the statistical history of the Peabody and Artisans' Block Buildings of London, where the density is 750 persons per acre. In 1884, these properties, consisting of 10,144 apartments, occupied by 18,453 persons, showed a birth-rate of 44·6 per 1000, or 10·9 higher than the general London rate; a death-rate of 19·1 per 1000, or 1·2 less; and an infantile mortality of 138·7 per 1000 births, or 13·7 less than the London average. On the general question of density Newsholme[1] says very properly: "It would be a mistake to suppose that the ratio of density to mortality demonstrated by Dr Farr is an inexorable law incapable of mitigation. The fact that the urban is generally decreasing in spite of increasing density, and is decreasing at a more rapid rate than the rural death-rate, is a disproof of this." Ogle has shown in his figures of the relation of density of population to mortality rates, that until the figure reaches 400 persons per square mile density is not an important factor.

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[1] *Op. cit.* p. 143.

Birth-Rate.—The birth-rate of a population is calculated from the number of births in the year as a rate per 1000 of the population living at the middle of the year :

$$\frac{\text{Number of births in the year}}{\text{Population in middle of year}} \times 1000 = \text{Birth-Rate.}$$

This is but an imperfect way of reckoning, since it takes no special count of the number of persons living at child-bearing ages, a figure which obviously will vary in different populations. A more accurate way, though also involving fallacies when comparison between one country and another, or one town and another, is made without correction for variations in numbers of women within child-bearing ages, would be to calculate the rate from the number of women in a population within the years of child-bearing. But even this could only properly be designated as a *live birth-rate*, since no count is taken of still-births ; therefore, a birth-rate must not in any case be reckoned as a *fecundity*-rate, even although the eventual figure might not be much different by the inclusion of the still-births. The illegitimate birth-rate is worked out in the same way.

The Effect of a high Birth-Rate upon the Death-Rate.—This has been a much-debated question for many years, and statisticians have been divided in opinion on the subject ; but the following statement may be taken as fairly expressive of the effect of a high birth-rate upon the death-rate of communities under different circumstances ; where a high birth-rate suddenly obtains from a sudden influx of young married persons to a community, by reason of employment or otherwise, the effect is undoubtedly to raise the death-rate, because of the relatively much higher mortality of infants under one year than at any other age-period. But should this high birth-rate be maintained continuously over a series of years, the result will be that the general death-rate is lowered, because its continuance contributes to the sum of those lives at ages at which mortality is lowest. Where the birth-rate on the other hand is lower than the average, it is contributory to an increase in the death-rate, for the reasons above given.

Decline in Birth-Rates.—With the exception, probably, of Germany, decline in the birth-rate is a significant feature of most of the nations of the world. France is barely making ends meet in new lives. Italy has but a small balance in its favour. In the United States of America the decline is marked. Although that country is, under regulated conditions, one of the main recipients of the emigrants from all parts of the globe, its increase of population in the decade ending 1900 only amounted to 20·7 per cent., having fallen to that figure from 24·9 per cent. in 1890, and from 30·1 per cent. in 1880. Even in such a young colony as New South Wales the increase of population was only better than France by the small margin of 3 per cent. It is a significant fact that since 1876 in England and Wales the birth-rate has progressively declined. In that year it stood at 36·3 per 1000, and in its progressive fall it reached in 1899 the figure of 29·2, in 1900 for the whole kingdom, 29 per 1000 of population, and in 1907, 26·3 per 1000. This last fact indicates in a total population of 41½ millions an annual deficiency in children since 1875 of about 250,000. In Scotland the same lowered birth-rate is found, and that notwithstanding the continued maintenance in ratio of the marriage-rate. In 1861–1870 the birth-rate per 1000 was 35, in 1871–1880, 34·86, in 1881–1890, 32·30, and in 1891–1900, 30·70. In all the counties of Scotland, except Kincardine, Nairn, and Kinross, it has declined between 1880 and 1899; and in Roxburgh, Clackmannan, and Selkirk the decrease has been very considerable. There can be little doubt that the main reason for this decline is due to prevention of conception by married persons.

Lewis in a critical inquiry [1] into the data obtained from the birth-registers for Scotland in 1855, founded as these were on the schedules of the first Registration Act for Scotland, the Act of 1854, and which contained more detailed information than subsequently owing to the limitation of inquiry laid down in the amending Act of 1856, has drawn attention to some very interesting facts derived therefrom. The details demanded in the Act of 1854 in respect of births were unique as to their comprehensiveness. The following facts emerged from his inquiry :—The total number of births in Scotland in 1855 was 93,369, of which 85,964 were legitimate and 7405 illegitimate births. Of the total legitimate births 44,010 were of males, and 41,954 of females, and these were the product or offspring of 84,971 wives. The illegitimate births were the offspring of 7319 mothers. The mean age of all the wife-mothers was 30·578 years, and of the total wife-mothers at all ages, 53 per cent. were under that mean age, and 47 per cent over it. Dividing the parturient ages of wife-mothers (15 to 58 years) into quinquennial groups, it was found that the age-group 25 to 29 contributed 28·12 per cent., and the age-group 30 to 34 years, 24·2 per cent., both together making 52·32 per cent. of the total legitimate births. The ages of the " husband-fathers " ranged from 17 to 86 years, and the year of age which gave the largest number of births was 30, the next highest being 28 years. The mean age of the 84,971 husband-fathers was 33·94 years, the number under that mean forming 38·6 per cent., and the number over it, 61·4 per cent. of the total number. This, it will be observed, was practically the reverse of the wife-mothers. The bulk of the children born in that year were of fathers whose age was over 30·5 years and of mothers whose age was under that figure. The comparative fertility—that is the " quantity of ascertained productiveness "—of the total female population of that year was greatest in the decade 25–34 years, and showed a decline after the age of 34 years. Male fertility was highest in the age-group 30 to 34 years, and next highest in the group 35 to 39 years, and not ten years earlier as in the other sex. The data with relation to the comparative fecundity—that is, the "quality of ascertained productiveness "—viz. 398,307 wives at child-bearing ages, and 84,971 fruitful wives, showed that one wife in five, or 21 per cent., was annually fruitful, that wives between the ages of 15 and 19 were most fecund (over 51 per cent. of these proved fruitful in any year), and that there was a falling off of 8 per cent. in the age-group 20 to 24, and a steady decline in each subsequent quinquennium. Of the husbands totalling 425,747, and of husband-fathers, 84,971, the fecundity showed (1) that there were 5 husbands for each husband-father. (2) that of each 100 husbands, 19·96 annually became fathers of living children, and (3) that the fecundity at each age-group was higher than that of wives at corresponding age-groups. Of multiple births in 1855, there were eleven triplet births, one of which instances was illegitimate—that is, once in 8497 legitimate deliveries, or once in 8391 deliveries over all, or at the rate of 119 per million. Since 1855 till 1901 inclusive, triple births have numbered 116 per million confinements. Twin births in 1855 occurred once in every 87·06 confinements. The female age at which the largest number of twins occurred was 30, the next being 35, the greatest number of fathers being over 30 years of age.

Lewis deals also with the masculinity of peoples. By the term masculinity he means the proportional preponderance of males over females at birth, the masculinity being positive where the males per 1000 females are in excess of that figure, and negative when they fall below that figure. The masculinity of a people, he points out, rarely exceeds 1100—*i.e.* 1100 males to 1000 female births—or falls below 900. Masculinity differs in different nations. In 1904, Greece and Roumania had the highest masculinity, France was very low, and the United Kingdom showed only a medium masculinity. In England and Wales in 1851–1860 it was 1046, the birth-rate being then 34·1 per 1000 of population, and in 1891–1900, 1036 with a birth-rate of 29·9 per 1000. In Scotland, in the same decades, the figures were 1057 and 34·1 and 1050 and 30·2 respectively. In France in 1851–1860 the figures were 1056 and 26·7, and in 1891–1900, 1041 and 22·2.

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[1] " Natality and Fecundity," 1905.

Sterility, which simply denotes in this case the absence of living registrable issue during conjugal existence at reproductive ages, was exhibited in the statistics of 1855 in the case of 17·8 per cent. of the wives ; or, put in another way, one in 5·62 appeared in the register of marriages but not in the register of births. Deducting the number of wives married at ages over 48 years, the percentage of sterile wives falls to 16·45 per cent., or 1 in every 6 wives proved unfertile. According to the data for 1855, it would seem, taking all ages together, that when a woman has been married for five years without issue, the probability that she will not conceive at all is about 17 to 1.

Notification of Births Act, 1907.—By the Notification of Births Act, 1907 (7 Edw. VII. ch. 40), in any district of a Local Authority in which the Act has been adopted—for the Act is only an adoptive Act—due intimation must be made to the Medical Officer of Health of the district of every child born within thirty-six hours after the birth "*which has issued forth from its mother after the expiration of the twenty-eighth week of pregnancy, whether alive or dead.*"

Section 1. Enacts that in the case of every child born in an area in which the Act is adopted, it shall be the duty of the father, if he is actually residing in the house where the birth takes place at the time of its occurrence, or of any person in attendance at the time of, or within six hours after, the birth, to give notice in writing of the birth to the medical officer of health by posting a prepaid letter or postcard addressed to that official at his office or residence, giving notice of the birth, within 36 hours after the birth, or by delivering a written notice of the birth at the office or residence of that official within the same time ; and the Local Authority shall supply without charge addressed and stamped postcards containing the form of notice to any medical practitioner or midwife residing or practising in their area, who applies for the same. Any person who fails to give notice of a birth as above shall be liable on summary conviction to a penalty not exceeding twenty shillings unless he satisfies the court that he had reasonable grounds to believe that notice had been duly given by some other person.

The notification required by this Act shall be in addition to, and not in substitution for, the requirements of any Act relating to registration of births ; and any registrar of births and deaths within any area in which this Act is adopted shall at all reasonable times have access to notices of births received by the medical officer of health under this Act or to any book recording the same, for the purpose of obtaining information concerning births within his district.

Section 2. Enacts that a Local Authority may by resolution adopt this Act in their area. According to the schedule of the Act, such resolution of adoption must be passed at a meeting of the council specially called for the purpose after notice of the intention to propose such resolution has been given to every member of council at least one calendar month before such meeting. Such resolution after being passed shall be published by advertisement in one or more newspapers circulating within the area of the council, and otherwise as the council may deem sufficient for giving notice thereof to all persons interested. A copy of such resolution of adoption shall be sent to the Local

Government Board, and the resolution of adoption shall come into operation not less than one month after first publication of the advertisement at such time as may be fixed by the Local Government Board, after consent of the Board.

As soon as consent of the Board is given, the Local Authority shall bring the provisions of the Act to the attention of all medical practitioners and midwives practising in their area.

The expression "Local Authority" used in the Act means the council of a borough (including the council of a metropolitan borough of the city of London), the council of an urban or rural district, and the council of a county (other than the county of London), who may adopt the Act either for their whole county or for any county district therein.

When the Act is adopted by a county council, the county medical officer of health shall be substituted for the medical officer of health of the district; and if, where the Act has been adopted by the council of a county for any county district, the council of the district, or where the Act has been adopted by the council of a county district for their district, the county council subsequently apply to the Local Government Board to be made the authority for the purposes of this Act, the Board may, if they think fit, make an order accordingly.

In London, the medical officer of health of every metropolitan borough (including the city of London) in which this Act is in force for the time being shall send weekly to the London County Council, in a form prescribed by the Local Government Board, a list of all notices of birth received by him under this Act during the past week.

Section 3. The Local Government Board may by order declare that this Act shall be in force in the area of any Local Authority who have power to adopt the Act, although it has not been so adopted, if they think it expedient, having regard to the circumstances of the area, such order to have the same effect as a resolution of adoption duly passed by the Local Authority of the area and assented to by the Board.

The Act is adoptive for England, Scotland, and Ireland.

According to the Births and Deaths Registration (Scotland) Act, 1854 (17 and 18 Vict. cap. 80), a registrar may call upon a medical practitioner to give information regarding the birth of a child.

The Marriage-Rate, as usually returned, is calculated from the annual marriages divided by the total population, and the quotient multiplied by 1000; it is, therefore, a ratio per 1000 of population, thus:

$$\frac{\text{Annual number of marriages}}{\text{Total population}} \times 1000 = \text{Marriage-Rate.}$$

Marriages are relatively more frequent in urban than in rural communities, chiefly because the sexes at marriageable ages are attracted to the populous centres by facilities of remunerative employment. It has been suggested that the rate would be better expressed as the annual marriages divided by the population of both sexes above the age of fifteen, and the quotient multiplied by 1000.

Death-Rates.—The annual death-rate of a population is reckoned from the number of deaths in the year divided by the population in the middle of the year and the answer multiplied by 1000, thus:

$$\frac{\text{Number of deaths in the year}}{\text{Population at middle of the year}} \times 1000 = \text{Death-Rate.}$$

But weekly, monthly, and quarterly death-rates in terms of 1000 per annum are also returned in statistical reports. The first is obtained by dividing the mean annual population by 52·17747, the exact number of weeks in a year, and thus arriving at the weekly population, by which the number of weekly deaths is divided; the product multiplied by 1000 gives the weekly death-rate in terms of 1000 per annum, thus:

$$\frac{\text{Number of deaths in the week}}{\text{Mean population} \div 52{\cdot}17747} \times 1000 = \text{Weekly Death-Rate per 1000 per annum.}$$

The monthly rate is obtained by dividing the mean annual population by 365·24226, the exact number of days in a year, and multiplying the quotient by the number of days in the month the rate of which is wanted. This gives the monthly population. Then the number of deaths in the month is divided by the monthly population, the product multiplied by 1000, and the answer is the monthly death-rate in terms of 1000 per annum, thus:

$$\frac{\text{Number of deaths in the month}}{\text{Mean population} \div 365{\cdot}24226 \times \text{number of days in month}} \times 1000 = \text{Monthly Death-Rate per 1000 per annum.}$$

The quarterly death-rate is obtained by a similar process, except that the daily population got as described is multiplied by the number of days in the quarter, to get the quarterly population, which when calculated into the number of deaths in the quarter and multiplied by 1000, gives the quarterly death-rate in terms of 1000 per annum. Where a medical officer is required to give weekly, monthly, and quarterly returns of the death-rate, in view of the fact that the number of days in a month and in a quarter varies, it is a convenient plan for a newly appointed officer, when he has arrived at the knowledge of the number of persons in his district, to make once and for all in each year a calculation of the daily population by dividing the total annual population by 365·24226, and preserving for ready reference the figure thus obtained. A weekly, monthly or quarterly population is thus easily obtained by multiplying this figure by the necessary number of days in the period, and is thus comparable with the number of deaths in the same respective periods, the result to be rendered in terms of a rate per 1000 of population per annum.

Corrections of Crude Death-Rate.—The death-rate so obtained is the *general* or *crude* death-rate, but it is susceptible of various corrections. Thus in any large population in which there are public institutions frequented by persons non-resident in that population, the deaths of such cannot be fairly debited in the returns of that population, and therefore must not be reckoned as part of the death-toll; in like manner the deaths of residents which take place outside the area must be included.

The second correction is that for sex- and age-distribution. As has already been stated, any population with an unusually large number of units at the extreme ends of life will have a higher death-rate than an average mixed community, and one having an unusual preponderance of females, a lower death-rate. In order, then, to make the death-rates of such places comparable with those of other places, corrections must be made for the incidence of age and sex. The Registrar-General gives factors for the principal populations, based upon these factors as ascertained at the previous census. These factors are obtained from the mean annual death-rate of the country for the decade prior to the last census for each age and sex, and calculated into the age- and sex-distribution of the area according to the last census. The total deaths thus calculated, multiplied by 1000, and divided by the population of the last census, give the *standard death-rate.* The mean annual death-rate of the country divided by the standard death-rate gives the *factor for correction*, which multiplied by the *recorded death-rate* gives the *corrected death-rate.* The factor for correction is, in most cases, greater than unity in the case of large populations, but not, as a rule, in small towns or rural districts. The *comparative mortality figure* is obtained by multiplying the *corrected death-rate* by 1000 and dividing by the death-rate for the whole country. The term "*standard death-rate*" signifies the death-rate at all ages calculated on the assumption that the death-rate of each of the eleven age-periods in any populous place was the same as in England and Wales during the previous intercensal decade. This standard death-rate is operative during the current decennial years, and is the means of correcting the annual death-rates in any populous place. The term "*factor for correction*" is the figure by which a recorded death-rate must be multiplied to correct for variations of sex-distribution and age-distribution in any populous place, or, in other words, is the figure obtained by dividing the annual death-rate of the country by the local standard death-rate. The "*corrected death-rate*" is the recorded death-rate multiplied by the factor for correction, or the death-rate which would have been recorded in a populous place, had the sex- and age-distribution therein been the same as that of the whole country. The "*comparative mortality figure*" is a figure obtained by reducing the *annual* death-rate of the country to 1000 and comparing the *corrected* death-rate of the place with it.

An example, which we quote from Newsholme,[1] will illustrate how these factors are obtained.

TABLE IV

Ages	Mean Annual Death-Rate of England and Wales 1881–1890, per 1000 living at each Group of Ages		Population of Huddersfield in 1891		Calculated Number of Deaths in Huddersfield	
	Males	Females	Males	Females	Males	Females
Under 5 . .	61·59	51·95	4551	4785	280	249
5— . .	5·35	5·27	4691	5081	25	27
10— . .	2·96	3.11	5113	5165	15	16
15— . .	4·33	4·42	4905	5549	21	25
20— . .	5·73	5·54	4541	5461	26	30
25— . .	7·78	7·41	7466	8834	58	65
35— . .	12·41	10·61	5576	6265	69	66
45— . .	19·36	15·09	3944	4649	76	70
55— . .	34·69	28·45	2393	3017	83	86
65— . .	70·39	60·36	1128	1590	79	96
75 and upwards	162·62	147·98	250	466	41	69
Total			44,558	50,862	773	799
			95,420		1572	

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[1] *Op. cit.* p. 110.

The *standard* death-rate for Huddersfield in 1891 thus works out:

$$\frac{1572 \times 1000}{95{,}420} = 16{\cdot}47 \text{ per } 1000.$$

The annual death-rate for England and Wales in 1881–1890 was 19·15; therefore the *factor* for *correction* for age and sex for Huddersfield is $\frac{19{\cdot}15}{16{\cdot}47} = 1{\cdot}1627$; in other words, the age- and sex-distribution in that town was much more favourable to a low death-rate than in the rest of England. The *corrected* death-rate for Huddersfield is, therefore, the *recorded* death-rate (16·47) multiplied by the factor for correction; thus $16{\cdot}47 \times 1{\cdot}1627 = 19{\cdot}149$ or 19·15 per 1000 per annum. The comparative mortality figure for that town is the corrected death-rate of the town—viz. 19·15, compared with the recorded death-rate at all ages in England and Wales in the same year—viz. 17·43, taken as 1000.

$$\text{thus } \frac{19{\cdot}15 \times 1000}{17{\cdot}43} = 1098.$$

Having ascertained the general death-rate of the community, death-rates according to sex, to age, and to certain classes of disease must be made out in order to indicate the conditions which bear upon life.

Death-Rates of Age-Groups.—The age-groups for which rates are calculated are twelve in number—viz.

Under one year—	5—	10—	15—	20—	25—	35—	45—	55—	65—	75—	85 and upwards

It may be said, generally, that the death-rates of the age-groups under 5 and over 55 are higher than the general death-rate for all ages; that the rate between 10–15 is the lowest; while between 5 and 25 the rate is lower than that at later ages.

Infantile Mortality.—This is reckoned by dividing the number of deaths of infants under one year by the number of births registered during the year, and multiplying the quotient by 1000, thus:

$$\frac{\text{Deaths of children under one year}}{\text{Births registered during the year}} \times 1000 = \text{Infantile Mortality.}$$

The incidence of infantile mortality varies in different countries of the world, and in different populous centres in any given State. It may be stated as a broad fact that high death-rates in children under one year of age prevail in all parts of the civilised world. If attention be confined to the United Kingdom, the following statistical tables will show the prevalence of the mortality in the first year of life:—

TABLE V

Deaths of Children under One Year in England and Wales, in London, and in the English Provinces for the Years 1891 *and* 1900

Male Infant Deaths

	Year	Under Three Months	Under Six Months	Under Twelve Months	Total under One Year
England and Wales	1891	37,912	15,266	23,079	76,257
London	,,	5,379	2,397	3,632	11,408
English Provinces	,,	32,533	12,869	19,447	64,849
England and Wales	1900	39,158	16,745	23,555	79,458
London	,,	5,575	2,459	3,518	11,552
English Provinces	,,	33,583	14,286	20,037	67,906

Female Infant Deaths

	Year	Under Three Months	Under Six Months	Under Twelve Months	Total under One Year
England and Wales	1891	28,609	11,874	19,061	59,544
London	,,	4,283	1,889	3,196	9,368
English Provinces	,,	24,326	9,985	15,865	50,176
England and Wales	1900	29,662	13,538	20,254	63,454
London	,,	4,269	2,080	3,138	9,487
English Provinces	,,	25,393	11,458	17,116	53,967

Summing these figures for both sexes who died under one year, there were 135,801 deaths in 1891, of which 20,776 occurred in London, and 115,025 in the provinces, and 142,912 in 1900, of which 21,039 happened in London, and 121,873 in the provinces. These gross totals must be compared with the total births in these respective years for each division of the country. But that the mortality figures are high is apparent by taking the infantile mortality in England and Wales for the same years. For males, the mortality rate in 1891 was 164, and in 1900, 169 per 1000 births, and for females, 133 per 1000, and 139 per 1000, in the same years respectively. The incidence of infantile mortality varies, as might be expected, in different parts of England. In counties which possess large urban or populous centres the rate is found to be higher than in those in which the population is mainly rural; thus, in the counties of Lancashire, Northumberland, and Durham, which contain large manufacturing centres, the average infantile mortality in 1901 was 197 for males and 163 for females per

1000 births, whereas in Rutland, Wilts, and Dorset, counties which are chiefly agricultural, the average mortality in the same year was 102 per 1000 for males and 88 per 1000 for female children.

The following figures, which are the most recent for England and Wales, were given by the President of the Local Government Board in answer to a question in the House of Commons:—

TABLE VI

I.—*Infant Mortality in each of the Years* 1904 *to* 1908

	Deaths under 1 Year to 1000 Births in the Years				
	1904	1905	1906	1907	1908
England and Wales . . .	145	128	132	118	121
76 great towns, including London .	160	140	145	127	129
London	145	130	131	116	113
142 smaller towns	154	132[1]	138	122	124
England and Wales, less the 218 towns	125	113[2]	116	106	110

II.—*Infant Mortality in the First Nine Months of each of the Years* 1904 *to* 1909

	Deaths under 1 Year to 1000 Births in the First Three-quarters of each of the Years					
	1904	1905	1906	1907	1908	1909
England and Wales	149	131	135	113	115	106
76 great towns, including London .	165	142	148	118	123	114
London	149	129	133	110	110	104
142 smaller towns	157	136[1]	140	118	117	107[3]
England and Wales, less the 218 towns	127	116[2]	117	104	105	97[4]

[1] 141 small towns.

[2] Less 217 towns.

[3] 143 small towns.

[4] Less 219 towns.

The following table shows the rates in several of the registration counties :—

TABLE VII

Infantile Mortality in English Counties and in Wales per 1000 *Births in* 1901

Registration County	Males	Females
Rutland	99	90
Wilts	101	80
Dorset	107	93
Westmoreland	109	79
Hertford	111	82
Buckingham	113	101
Huntingdon	115	76
Somerset	117	89
Hereford	118	92
Berkshire	119	95
Shropshire	119	100
Sussex	121	103
Oxford	122	89
Gloucester	125	105
Bedford	128	97
Cambridge	128	99
Surrey	129	100
Hampshire	136	113
Devon	136	107
Middlesex	138	122
Cornwall	139	105
Cumberland	141	117
Suffolk	142	106
North Wales	148	125
Kent	149	111
Worcester	149	120
Lincoln	153	125
Norfolk	157	113
Yorks (North Riding)	158	140
Essex	159	133
London	162	136
Derby	164	113
Leicester	167	138
Monmouth	167	144
Cheshire	171	138
Yorks (East Riding)	177	143
Stafford	181	146
Yorks (West Riding)	184	152
Warwick	184	151
Nottingham	186	157
South Wales	187	153
Durham	194	164
Lancashire	196	162
Northumberland	201	163
England and Wales	166	136

A brief consideration of the foregoing table will indicate at once that those counties in which infantile mortality rates are highest are the counties which are largely given over to industrial operations, in several of which women are much employed while, perhaps, suckling their infants, or who, because of such employment, are either unable to perform this maternal duty or neglect it.

The statistical records of Scotland bear out the same conclusions, as is shown in the following tables :—

TABLE VIII

Deaths of Infants under One Year in 1891 *in Different Districts of Scotland*

	Total Births	Deaths Under Three Months	Deaths Under Six Months	Deaths Under Twelve Months	Total Deaths under One Year
Scotland . . .	125,986	8,211	2,890	5,009	16,110
Principal Towns .	52,407	3,782	1,333	2,598	7,713
Large ,, . .	15,883	1,077	368	615	2,060
Small ,, . .	26,860	1,700	672	1,026	2,389
Mainland Rural Districts	27,977	1,499	476	692	2,667
Insular Rural Districts	2,859	153	41	78	272

Table for 1900

	Total Births	Deaths Under Three Months	Deaths Under Six Months	Deaths Under Twelve Months	Total Deaths Under One Year
Scotland . .	131,401	8,626	3,220	5,042	16,888
Principal Towns .	57,089	4,131	1,604	2,652	8,387
Large Towns . .	18,686	1,245	500	783	2,528
Small Towns . .	28,459	1,804	640	1,010	3,454
Mainland Rural Districts	24,582	1,317	453	555	2,325
Insular Rural Districts	2,585	129	23	42	194

TABLE IX

Infantile Mortality in Scotland and in Group-Areas per 1000 *Births and for Both Sexes under One Year of Age, for* 1891 *and* 1900

	1891	1900
Scotland—Average of all . . .	127·8	128·5
Principal Town Districts . . .	147·2	146·9
Large Town Districts	129·7	135·3
Small Town Districts	126·5	121·3
Mainland Rural Districts . . .	95·3	94·5
Insular Rural Districts	95·1	75·0

TABLE X

Infantile Mortality per 1000 *Births in the Principal Towns of Scotland*

Town	1891	1900
Glasgow	166·9	172·8
Edinburgh	140·5	154·0
Dundee	203·2	199·2
Aberdeen	149·8	177·8
Leith	145·1	135·2
Paisley	157·8	144·7
Greenock	161·6	152·5
Perth	114·3	145·6
Kilmarnock	135·0	128·8
Govan and Partick	. .	156·1
Coatbridge	. .	145·9

These tables indicate differences in incidence of mortality among infants which point not only to differences in hygienic conditions but also to the custom of mothers in rearing their infants. Artificial feeding prevails much more in town populations than in rural populations; indeed it is the exception in a Scottish rural district to find an infant being bottle-fed. The highest rates also obtain in those towns in which mothers are most employed in industry. This is notably the case in Dundee, Glasgow, and Greenock.

Diseases which contribute chiefly to Infantile Mortality.—When the registered causes of deaths of infants under one year are analysed, it is found that they resolve themselves into well-defined groups. A serviceable classification of group-causes is as follows:—(*a*) infectious diseases; (*b*) diarrhœal diseases; (*c*) tubercular diseases; (*d*) meningitis and convulsions; (*e*) lung diseases; (*f*) wasting diseases; and (*g*) other causes. Under the heading of diarrhœal diseases are grouped those certifiable causes of death which are referable to the gastro-intestinal tract—viz. diarrhœa and epidemic diarrhœa, enteritis (infective), English cholera, gastric catarrh, enteritis and gastro-enteritis; of tubercular diseases: phthisis, pulmonary tuberculosis, tuberculous meningitis, tuberculous peritonitis, tabes mesenterica, general tuberculosis, and other bodily tuberculous diseases; of wasting diseases: immaturity, premature birth, birth debility, injury at birth, congenital defects and deformities, atrophy and marasmus.

If the mortality per 1000 infants under one year in England and Wales be divided into percentages, the relative incidence of deaths from these causes will be discovered. Of the 164 deaths per 1000 male infants which occurred in 1891, infectious diseases contributed 5·5 per cent., diarrhœal diseases, 9·15 per cent., tuberculous diseases, 6·1 per cent., meningitis and convulsions, 15·8 per cent., lung diseases, 20·74 per cent., wasting diseases, 28·65 per cent., and other causes 14·06 per cent.; of the 133 female deaths per 1000 in the same year, these groups gave the following percentages respectively—viz. 7·5, 9·8, 6·0, 15·04, 20·3, 28·56 and 12·8 per cent. Of the 169 deaths per 1000 male infants in 1900, following the same order of groups, the respective percentages of deaths from these groups were respectively as follow—viz. 5·9, 19·5, 4·74, 13·0, 16·56, 29·5 and 10·8 per cent.; and of the 139 deaths per 1000 female births: 6·5, 20·15, 4·0, 12·0, 15·8, 28·8, and 12·75 per cent. respectively.

It will be observed that in the above-named groups nothing has been said of such congenital diseases as, for example, syphilis, although it is by no means unknown. Probably syphilis is included under some other designation, for reasons which will probably suggest themselves.

The following table details still further the causes of infantile mortality:—

TABLE XI

England and Wales 1907

Causes of Infantile Mortality—Males and Females

Cause of Death	Deaths under One Year of Age per 1000 Births
All Causes	117·62
Premature Birth and Congenital Defects	26·45
Bronchitis and Pneumonia . .	23·26
Atrophy	15·01
Diarrhœal Diseases	14·06
Convulsions	11·06
Whooping-Cough	5·16
Measles	3·00
Phthisis	0·40
Other Forms of Tuberculosis . .	4·14
Diphtheria	0·30
Diseases of Heart and Blood Vessels .	0·04
All other Causes	14·74

In 1908 the infantile mortality rate in Glasgow was 136 per 1000 births, the death-rate per cent. being from (*a*) Immaturity, 31·6 per cent., (*b*) diseases of the respiratory system, 21·0 per cent., diseases of the digestive system, 19·0 per cent., of the nervous system, 6·6 per cent., tuberculous diseases, 4·1 per cent., accidents of birth, 0·8 per cent., infectious diseases, 12·9 per cent., syphilis, 0·9 per cent., suffocation, 1·0 per cent., other violence, 0·3 per cent., and all other causes 1·8 per cent.

Diarrhœal diseases in infants vary much in incidence according to the season of the year. They may be said to increase rapidly in number in July, to reach their maximum in August and September, and to diminish rapidly thereafter in the early winter months; but as their incidence very largely depends upon the use of unclean vessels in which milk is stored and of unclean bottles from which infants are fed, as well as inappropriate kinds and amounts of food given, they prevail more or less throughout the year. There can be little doubt that they are microbic in causation. Budin pointed out[1] that of every 1000 infants who die in Paris, 380 die from diarrhœa; in Rouen, 510; in

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[1] Budin, *Journal Obstétrique*, Jan. 1903.

Dijon, 584; and in Troyes, 682; and that of 69 infants who died of diarrhœa at Boulogne, only 8 were suckled by the mother, 20 being brought up on the bottle, and 41 fed on different forms of food.

Causes of High Prevalence.—These may be divided into two classes—viz. (*a*) unavoidable, and (*b*) preventable.

Under the former may be included (1) premature birth, (2) injury at birth, (3) congenital defects and deformities, and (4) congenital diseases. There is no doubt that much waste of infant life is due solely to marriage between parents of unhealthy stock. The procreative faculty is not confined to women of robust or even of good health, but is existent to no small degree in women of indifferent or even weak health. Less care is being exercised in the present day in the marital unions of human beings than in the mating of cattle or horses. Irrespective, therefore, of good sanitary environments and circumstances, weakly infants will continue to be born of such marriages.

The preventable or avoidable causes may be grouped as follows:—(1) insanitary domestic conditions, (2) vicious and objectionable habits and modes of life of parents, (3) parental poverty, (4) occupation of mothers during the early months of child-nursing, (5) wilful or compulsory abstinence of mothers from suckling their infants, and (6) physical unfitness of mothers from other causes for that duty.

Infantile Mortality in relation to Declining Birth-Rates.—The prevalent and continuous high rates of infantile mortality attain a higher significance because of the gradual diminution in numbers of infants born which has been taking place during the last thirty years; indeed, the question has arrived at the point to awaken national concern. If the high prevailing infantile mortality, which persists in spite of advancing sanitation, and the gradually declining birth-rate be connoted, the significance of the relationship and the need for inquiry by statesman and sanitarian alike demand attention.

Preventive Measures.—These may be briefly summed up as follows—viz. (*a*) State measures, (*b*) municipal measures, (*c*) philanthropic effort.

The Acts of Parliament which have been passed for the protection of infant life, such as the Friendly Societies Act, 1875, which prevents the over-insurance of infants, the Notification of Births Act, 1907, and the Children Act, 1908, which regulates baby-farming among its many other provisions, are all in the right direction. It is, as yet, a moot question whether the Legislature should not be asked to pass an Act whereby women who are employed industrially should be forbidden to resume their employment until the expiration of a full month, at least, after delivery. By so limiting the time when work might legally be resumed, the State would be following certain provisions of the Factories and Workshops Acts which limit the hours of labour of young persons and women.

Municipal measures may be divided into two classes—viz. (1) administrative and (2) educational. Experience has shown that much of the mortality of infants is attributable to negligence and ignorance on the part of young mothers. It has been too much taken for granted that all women who bear children are instinctively able to care properly for them. Certain Local Authorities, through the agency of sanitary and registration offices, have for long been giving pamphlets or leaflets explanatory of the best modes of caring for and rearing infants to those concerned; and such a practice is good, so far as it goes. But something more is needed. Nothing short of practical demonstration of approved methods of rearing children, and especially of the artificial methods of feeding infants, where required, will suffice. Such a duty might, with great advantage, be imposed on trained women appointed by Local Authorities for this and other domiciliary purposes. This practice, where it has been initiated, has been followed by beneficial results. The experiment made in Salford is illustrative. In that town the average infantile mortality per annum between 1895 and 1900 was 211 per 1000 births, and in 1901 was 205 per 1000. The Local Authority appointed trained women to a district of the town called Greengate. In this district the mortality in 1900 was 224 per 1000 births, in 1901, 246 per 1000, but in 1902, after the conclusion of a year's experiment, the rate fell to 178 per 1000. Making all due allowance for other conditions, it would be not unfair to say that the experiment was, probably, no unimportant factor in the result. During the currency of the experiment the feeding of 494 infants was observed and supervised. Of that number 384 were reared exclusively on the milk of the mother, and 39 died, giving a rate of 104 per 1000; 65 were fed on food supplementary to the milk of the mother, of whom 10 died—a rate of 154 per 1000; 30 were reared artificially on the milk of the cow, of whom 12 died, the mortality being at the rate of 400 per 1000; and 25 were fed on other foods, of whom 11 died, showing a rate of 440 per 1000.

Of the administrative preventive measures, perhaps the most important which has been instituted is the municipal depôt for the purpose of sterilising and humanising the milk of cows for infant feeding and of supplying the same at reasonable cost. Begun in Fécamp in Normandy, the plan has been adopted by several municipalities in the United Kingdom. The milk so prepared is put in bottles containing the kind and amount suitable for infants of different ages, each bottle containing one meal. Another proposal is the establishment of public *crêches* wherein infants may be tended at a minimum cost what time the mothers are compulsorily employed. Philanthropic efforts are being directed toward district friendly supervision of the homes of mothers of infants. Such efforts, so far as they have gone, have proved beneficial.

One of the significant features of preventive medicine in these days is that, while before the march of sanitary progress general mortality rates are exhibiting a gradual decline, the number of deaths of infants under one year of age per 1000 births continues to remain unduly high in many of our populous centres. This is shown in the following table:—

TABLE XII

Showing Rates of Infantile Mortality in Some Cities in England and Scotland

Cities	Death-Rate per 1000 Births		
	1888–1897	1898	1899
Manchester	185	197	206
Birmingham	180	191	191
Leeds	178	182	171
Sheffield	180	195	194
Liverpool	189	184	198
Aberdeen	141	158	143
Dundee	176	182	170
Edinburgh	140	144	151
Glasgow	146	156	152

In the principal English towns for 1901 the rates varied from 126 per 1000 up to 226 per 1000, the latter rate being in Burnley, the next highest being Preston with a rate of 216 per 1000.

It would be for the present Utopian to expect in our populous centres rates corresponding to those in the purely agricultural counties, but that the rates obtaining in the former are capable of being reduced considerably admits of little doubt. An ideal rate to be aimed at would be 110 to 120 per 1000 births.[1]

Age-Group Mortality.—For any age-group, the death-rate is obtained by dividing the number of deaths in the group by the number of persons living at the same ages, and multiplying the quotient by 1000. In this way the total deaths in a population may be divided into the twelve age-groups given, and the death-rates therefor accordingly calculated.

The proportion of persons living at different age-groups will be seen in the following table :—

TABLE XIII

Table of Age-Groups per 1000 *of Population of England and Wales in* 1895

Ages	Persons
Under 5	120
5—15	228
15—25	196
25—35	147
35—45	113
45—55	87
55—65	59
65—75	35
75—85	13
85 and upward	2
	1000

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[1] Author, *Trans. Med. Chir. Soc. Glas.*, 1903–1904.

The percentage proportion of deaths at each age-group is as follows :—

Ages	Deaths per cent.
Under 5	37·4
5—10	2·9
10—15	1·6
15—20	2·3
20—25	2·7
25—35	5·8
35—45	7·0
45—55	8·1
55—65	9·8
65—75	11·8
75—85	8·5
85 and upward	2·1
	100·0

The Local Government Board of Scotland require medical officers of health to make a return of the mortality at the subjoined ages—viz.

All Ages
Under 1 Year
1— 5
5—15
15—25
25—60
60 and upward.

There are two fallacious methods of estimating the rate of mortality at different ages :

(1) To calculate the proportion of deaths in any age-group to the total deaths ;

(2) To calculate the proportion of deaths at various age-groups to the population at all ages.

They are fallacious in respect that they compare incomparable things. The fallacy underlying the former consists in the fact that either a diminution in the total deaths or an increase in the deaths in any age-group would increase the proportional deaths at the age-group under consideration, and in the latter method that, quite apart from any conditions inimical to health, the number of deaths at different age-groups, and therefore the proportion of these to the entire population, will vary with the number living at the age-groups in question. For small populations it is not advisable to have too limited divisions of age-groups owing to the error which would arise from paucity of data.

Death-Rates of the Sexes.—At birth, the number of males is greater than that of females, but at all other ages, except between 5 and 14, females preponderate in numbers, and taking the mean of all ages there are 1060 females in the population of Great Britain to every 1000 males. At all ages the expectation of life of a female is greater than that of a male ; consequently in any population in which the proportion of females to males is higher than the normal, the death-rate is correspondingly lowered. If we differentiate, therefore, between the death-rate of the sexes, it will be found that except between the ages of 10 and 25 the female death-rate will be lower than the male. In England and Wales in the decade 1881–1890, the former was 18·1, and the latter 20·2 per 1000 per annum.

TABLE XIV

Annual Rate of Mortality in England and Wales in 1891–1900 *for Each Sex in Age-Groups and for Both Sexes*

1891-1900	Ages	Males	Increase or Decrease from 1881-1891 per cent.	Females	Increase or Decrease from 1881-1891 per cent.	Both Sexes	Increase or Decrease from 1881-1891 per cent.
	All Ages	19·32	−2·4	17·14	− 3·4	18·19	−2·9
	0−	62·71	+ 1·8	52·80	+ 1·7	57·74	+ 1·7
	5−	4·31	−19·4	4·37	−16·9	4·34	−18·1
	10−	2·45	−16·9	2·57	−17·4	2·51	−17·2
	15−	3·79	−12·3	3·67	−17·0	3·73	−14·6
	20−	5·06	−11·7	4·46	−19·5	4·74	−15·8
	25−	8·76	−13·0	6·08	−17·6	6·40	−15·3
	35−	11·50	− 7·3	9·59	− 9·4	10·51	− 8·3
	45−	18·95	− 2·2	14·74	− 2·4	16·76	− 2·2
	55−	34·95	+ 0·7	28·44	− 0·1	31·47	+ 0·3
	65−	70·39	− 0·1	60·72	+ 0·5	65·04	+ 0·1
	75 up	160·09	− 1·6	146·46	− 1·1	152·17	− 1·4

TABLE XV—GLASGOW, 1881–1890

Average Annual Mortality per 1000 *living at Different Age-Groups*

Ages	Males	Females
0—5 . . .	86·24	75·52
5—10 . . .	10·65	10·14
10—15 . . .	5·52	5·33
15—20 . . .	7·24	7·13
20—25 . . .	7·93	8·94
25—35 . . .	9·34	10·99
35—45 . . .	15·28	14·25
45—55 . . .	26·50	21·54
55—65 . . .	45·81	38·42
65—75 . . .	84·31	70·21
75—85 . . .	149·47	123·75
85—95 . . .	262·17	221·08
95 and upwards .	260·87	300·00
All ages . . .	25·01	23·66

Zymotic Diseases Rates.—In like manner death-rates may be calculated for Diseases or Groups of Diseases. As an indication of the sanitary condition of a district, a special return is made called the *Zymotic Death-Rate.* This, however, only includes the deaths from the seven principal zymotic diseases—viz. small-pox, measles, scarlet fever, fever (which includes typhus, simple, continued, and enteric), diphtheria, whooping-cough, and diarrhœa, and omits returns of deaths from erysipelas, puerperal fever, and others; thus the zymotic death-rate does not conform to the diseases scheduled in the Infectious Disease (Notification) Act. It ought, therefore, to be clearly understood that the zymotic death-rate, as presently computed, is not a correct return of the death-rate from all zymotic diseases; but, at the same time, it is a valuable index of the health-conditions of a district. It may be computed and returned in more than one way—viz. (1) *as a proportion of deaths to numbers attacked;* (2) *as a proportion of deaths to the total deaths;* (3) *as a proportion of deaths from each zymotic disease per thousand or million of population.*

The value of the first method will entirely depend on the number of units from which the calculation is made; the larger the number the nearer the result to the truth, the smaller, the reverse. The second method shows the proportion of deaths from these diseases to the total deaths in a population, but it is fallacious when used for comparison. The third method is, probably, the best method of stating the death-rate from any specified zymotic disease, but it is only applicable to huge masses of population, such as a country or a nation, with a view to approximation to the truth.

The first method, although sometimes used for the purpose of drawing inferences, or making deductions regarding the effects of a particular line of treatment, is liable to the following possible errors—viz. (*a*) paucity of number of observations, and hence erroneous deductions made therefrom; any theory or conclusion based upon percentages derived from a relatively small number of cases should always be accepted with caution, owing to the margin of probable error; (*b*) the composition of the groups—viz. (1) the deaths, and (2) the recoveries: these when compared may have different age- and sex-constitution; it has to be remembered that death-rates, especially from certain diseases of the zymotic group, are not a little influenced by age at least, and to a more limited degree, perhaps, by sex; (*c*) type or virulency of the disease. It is well established that in different epidemics the virulency of the disease differs, and hence the case-mortality and the recovery-rate respectively are bound to bear different percentage-ratios to one another, and, further, that during the currency of an epidemic the virulency is usually greater at the commencement of the outbreak than later.

The second method is fallacious because it institutes a ratio or proportion between two factors in the problem both of which are variable—viz. the mortality from the particular zymotic disease or group of diseases, and the mortality from all causes. It may very well happen in any series of years either that the total deaths are relatively lower than usual and the zymotic deaths relatively higher, or the reverse.

The third method is undoubtedly the best. It is more applicable, and more accurate, to large populations, such as of a country or nation.

A still more satisfactory and correct method is not to return a death-rate for a group of zymotic diseases which is, at best, apt to lead to confusion, but to return an individual rate for specified individual diseases comprehended in the zymotic group. The principal zymotic diseases for which returns are given by the Registrars-General, and which are asked of medical officers of health, are (1) small-pox, (2) diphtheria, (3) scarlet fever, (4) typhus fever, (5) enteric and doubtful fevers, (6) measles, (7) whooping-cough, (8) diarrhœa, (9) pneumonia, and (10) septic diseases.

The following table shows the annual mortality in England and Wales for both sexes in the decennia 1881–1890 and 1891–1900 for different diseases of the zymotic group.

Table XVI

Annual Deaths per Million Persons living of Both Sexes

Causes of Death	1881-1890	1891-1900	Difference in 1891-1900	
			Annual Increase	Annual Decrease
Small-pox	44	13	—	31
Measles	406	414	8	—
Scarlet Fever	312	158	—	154
Influenza	20	361	341	—
Whooping-Cough	414	377	—	37
Diphtheria	153	263	110	—
Croup (not membranous)	133	51	—	82
Enteric Fever	198	174	—	24
Diarrhœal Diseases	631	738	107	—
Puerperal Fever and Childbirth	161	152	—	9
Pueumonia	1,041	1,227	186	—
Tuberculosis (all forms)	2,429	2,010	—	419
Phthisis	1,775	1,391	—	384
Tuberculous Meningitis	234	216	—	18
Tuberculous Peritonitis (Tabes Mesenterica)	257	217	—	40
Tuberculous Diseases (other forms)	163	186	23	—

Basing the zymotic death-rate on the zymotic diseases of the English Registrar-General — viz. small-pox, measles, scarlatina, diphtheria, fevers, whooping-cough, and diarrhœa, it will be seen from the following table that the rate is becoming lowered.

TABLE XVII

Zymotic Mortality in England and Wales, and in English Large Towns, per 1000 *of Population, from* 1889 *till* 1907 *inclusive*

Year	England and Wales	English Large Towns
1889	2·40	2·72
1890	2·05	2·77
1891	1·83	2·41
1892	1·90	2·63
1893	2·47	3·17
1894	1·76	2·43
1895	2·14	2·82
1896	2·18	2·90
1897	2·15	2·87
1898	2·22	2·85
1899	2·21	2·81
1900	2·00	2·50
1901	2·05	2·68
1902	1·64	2·12
1903	1·46	1·89
1904	1·94	2·49
1905	1·52	1·88
1906	1·73	2·24
1907	1·26	1·54

The succeeding table shows the rates per million persons living from each of the zymotic diseases in the foregoing list, and gives a consecutive history regarding these since 1838.

TABLE XVIII

England and Wales

Death-Rates from the Principal Epidemic Diseases per Million Persons Living, 1855–1904

Period	Small-pox	Measles	Scarlet Fever	Diphtheria	Whooping-Cough	Fevers			Diarrhœal Diseases
						Typhus	Enteric	Undefined	
1838–1842	576	539	797		504	1053			298
1847–1850	292	403	884		480	1246			1710
1851–1860	222	412	982		505	913			1088
1861–1870	162	443	971	187	530	886			1076
1871–1880	245	379	719	121	513	58	326	105	942
1881–1890	46	441	338	163	451	15	198	25	677
1891–1900	13	414	158	263	378	3	174	6	734
1901	10	276	133	273	313	1	155	3	924
1902	75	392	148	236	297	2	126	3	426
1903	23	274	125	182	285	2	100	2	551
1904	15	363	111	170	352	1	93	2	876

TABLE XIX

Showing Zymotic Diseases Rates in Certain English and Scottish Cities, per 100,000 *Living*

City	1891-1900	1901
Glasgow	308	328
Edinburgh	209	241
Dundee	226	289
Aberdeen	205	127
London	271	225
Liverpool	332	366
Manchester	338	343
Birmingham	289	316

TABLE XX

Showing Mortality per Million Persons Living in England and Wales and Scotland from 1871 *till* 1900

	Zymotic Disease	1861-1870	1871-1880	1881-1890	1891-1900
Eng. and Wales	Enteric Fever	—	322	198	174
Scotland	,,	—	390	230	180
Eng. and Wales	Measles	391	378	406	414
Scotland	,,	Much the	same figu	res and p	rogress
Eng. and Wales	Scarlet Fever	890	649	312	156
Scotland	,,	910	780	290	190
Eng. and Wales	Diphtheria	171	112	153	263
Scotland	,, Has undergo	ne steady an	d continuous	diminution	since 1864
Eng. and Wales	Croup	219	149	133	51
Scotland	,,	(see	remarks f	or diphth	eria)
Eng. and Wales	Tuberculosis (all forms)	3239	2862	2429	2010
Scotland	,,	3620	3470	2750	2370
Eng. and Wales	Phthisis	2545	2190	1775	1391
Scotland	,,	2560	2390	2000	1690

The fatality-rate or case-mortality is a rate per cent., and is used to express the numbers of those who die from a given disease per 100 of those attacked.

The morbidity-rate is a term used to express the proportion of those who sicken from a given disease or group of diseases like the zymotic group, per 1000 of the population per annum.

The fatality-rate in enteric fever in the Metropolitan Fever Hospitals has gradually fallen from 18·6 per cent. in 1897 to 13·15 per cent.

in 1905, and in the Glasgow hospitals from 15·3 per cent. in 1895 to 11·9 per cent. in 1905; in scarlet fever, both in the London and Glasgow fever hospitals, there has also been a steady fall, in the latter the rate being 20 per cent. in 1866–1870 had fallen to 6·3 per cent. in 1891–1894.

The mortality-rate in diphtheria per million persons living has in Scotland, as in England, exhibited a rise in the rate. In Table XX, which deals with the rates from individual zymotic diseases, it will be observed that in England and Wales with respect to the mortalities from diphtheria and croup respectively, in the later decades as the mortalities from the former increase the mortalities from the latter decline. This is probably the reason why diphtheria is believed to be on the increase, since cases which were formerly ascribed to croup, because of the prominence of the laryngeal symptoms, are now, because of bacteriological diagnosis, more truly diagnosed as diphtheria. Since 1864 the statistics of diphtheria and croup show a fairly steady and continuous diminution. From 1884 up to 1906 considerable improvement has occurred in England and Wales and in Scotland in the mortality rates, in the former having fallen from about 460 per million living in 1884 to about 160 per million in 1906, and in the latter from about 355 per million in 1884 to about 170 per million in 1906. This must be in the main attributed to the antitoxin treatment of the disease.

With regard to small-pox it is satisfactory to note that all over the United Kingdom there has been a steady and marked diminution in the number of cases and in the death-rate of small-pox. There cannot be the shadow of a doubt in the minds of unbiassed persons who study the facts that this is due almost entirely to the prevalence of vaccination, but there can be hardly as little doubt that within the next fifteen or twenty years there will be a steady increase of the disease owing to the gradually increasing constituency of unvaccinated persons.

The zymotic death-rate, or, better, the rates of individual zymotic diseases, is a good test in some respects, and up to a certain point, of the sanitary condition of a place. It has to be borne in mind that zymotic diseases, and, particularly, certain of them, occur in cycles, depending in large measure upon the growth of a young and, therefore, susceptible and vulnerable population. This is, perhaps, truest of measles, chicken-pox, whooping-cough, and scarlet fever. Others, again, depend very largely upon the accident of circumstances, such as the outbreak of cholera in Hamburg in 1892–1893, and outbursts of enteric fever from contaminated water-supplies; and these, added to diphtheria, may have their origin in insanitary conditions; while enteric fever, scarlet fever, and diphtheria may be due to contaminated milk-supplies. Typhus fever is not uncommonly an indication of overcrowding, coupled, perhaps, with some privation. In any of the zymotic diseases, moreover, it must not be forgotten that the mortality experienced in a given epidemic may be much higher than the normal owing to a more virulent type of the organism which produces the disease, and, in the case of measles and whooping-cough especially, to the climatic conditions during the currency of the outbreak.

In the same way a Death-Rate for Respiratory Diseases and a

Death-Rate for Phthisis may be computed in urban communities (*vide* Table XXI).

TABLE XXI

Table showing Death-Rates per 1000 *of Population from different Zymotic Diseases, Phthisis, and Respiratory Diseases in England and Wales in different Years*

Disease		1851-1860	1871-1880	1881-1890	1891-1895
Small-pox		·221	·236	·045	·020
Measles		·412	·378	·44	·40
Scarlet Fever		·876	·716	·33	·18
Diphtheria		·109	·121	·16	·25
Whooping-Cough		·503	·512	·45	·39
Fever	Typhus Fever	·908	·06	·015	·004
	Enteric Fever		·32	·20	·17
	Continued Fever		·10	·025	·008
Diarrhœal Diseases		1·080	·935	·67	·65
Zymotic Death-Rate		4·109	3·47	2·36	2·07
Phthisis		2·68	2·12	1·72	1·46
Respiratory Diseases		3·02	3·90	3·73	3·74

In the quinquennium 1891–1895 it may therefore be said that the death-rate per 1000 of population from the principal zymotic diseases was as follows:—small-pox, ·020 per 1000, or 20 per million; measles, ·40, or 400 per million; scarlet fever, ·18, or 180 per million; diphtheria, ·25, or 250 per million; of typhus fever, ·004, or 4 per million; enteric fever, ·17, or 170 per million; continued fever, ·008, or 8 per million; diarrhœal diseases, ·65, or 650 per million.

TABLE XXII—SCOTLAND, 1890–1892

Table showing Age-Distribution of Deaths from Whooping-Cough, Measles, Scarlet Fever, Enteric Fever and Diphtheria

Disease	Under 1	—2	—3	—4	—5	—10	—15	15—	All Ages
Whooping-cough	403	310	124	65	41	55	1	1	1000
Measles	214	386	167	80	48	87	5	15	1000
Scarlet Fever	75	136	148	136	108	254	74	69	1000
Enteric Fever	4	13	17	20	18	122	135	671	1000
Diphtheria	76	175	144	137	119	249	48	52	1000

Graphic or diagrammatic methods for presenting statistical facts are now largely employed. They possess the advantage over columns of figures, which always require careful study, that they enable the observer to comprehend more quickly the facts so portrayed. The following figures represent two of these forms (Figs. 1, 2).

Urban and Rural Death-Rates.—Urban death-rates are usually higher than rural death-rates, even after the usual corrections have

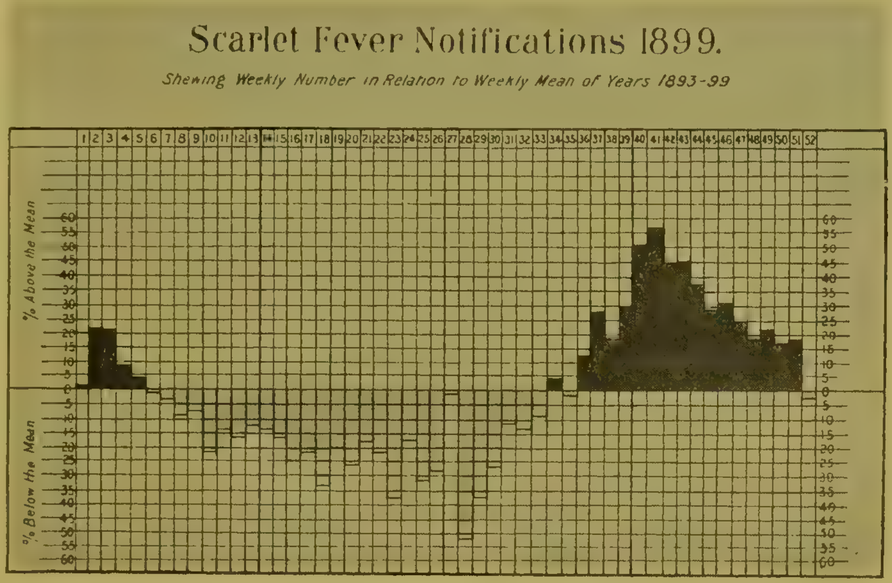

FIG. 1 illustrates one of the graphic methods of presenting statistical facts. The above figure is intended to show the percentage in the Weekly Returns of Scarlet Fever Notifications in Glasgow for 1899 above or below the Weekly Mean for the years 1893-1899. A glance at the figure at once shows whether in any given week the percentage of notifications was above or below the mean of the same week during the years above given. The mean for each week of the period 1893-1899 is taken as a standard figure, with which the notification returns of each week in 1899 are compared and contrasted. (Report Med. Off. Health of Glasgow for 1899 and 1900.)

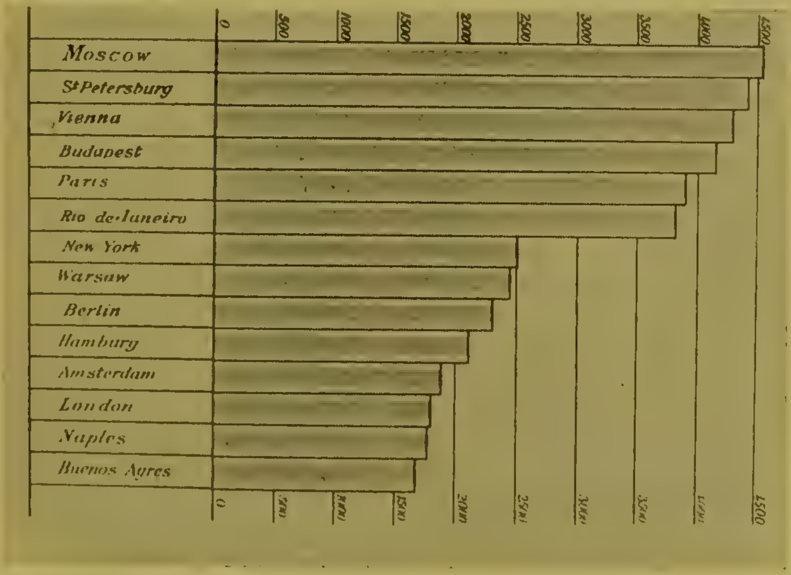

FIG. 2 illustrates as Death-Rates per Million of Population the prevalence of Tuberculosis in the Capitals of several Countries of the World. (City of Edinburgh Report on Tuberculosis, 1900.)

been made. This is due to a variety of factors—viz. density of population, artificial conditions of life, occupation, etc.

In rural districts and small villages, any figure between 10 and 16 per 1000 may be reckoned as fair average death-rates; in towns with populations varying between 5000 and 20,000, 15 to 18 per 1000; in cities of 30,000 to 100,000, 17 to 20 per 1000; and in large cities of over 100,000 of population, 18 to 21 per 1000. The death-rates for England and Wales, and for Scotland, have undergone progressive diminution during the last fifty years; for example, while the rate for England and Wales was 23·3 in 1846–1850, 22·4 in 1866–1870, 20·8 in 1876–1880, 18·9 in 1886–1890, it further fell to 18·7 in 1891–1895. In the large English towns, it has fallen from 24·7 in 1851–1860 to 20·2 in 1881–1890. In Scotland a like progressive diminution has been recorded in the principal towns, and in the country generally. Of the latter, in 1900 the rate was 19·070 per 1000.

LIFE TABLES

A life table, or biometer as it was named by Farr, is a means of measuring or estimating under certain defined conditions the probabilities of life and death either of the population generally, or of ages or groups particularly, and indicates the progressive history of life and death of a generation of individuals from the time all begin to live until all have ceased to live. Such tables are founded upon the number and ages of those who live, and the number and ages of those who die. Founded upon these tables are the operations of assurance companies with reference to insurance at death, and to annuities during life, all based upon the probabilities of living and dying which the results of the calculations in the tables show.

The earliest life-table dates back to the second half of the seventeenth century, having been constructed by Halley, the English astronomer, on the deaths in Breslau in the years 1687–1691. He did not, however, in his table differentiate between males and females. Based on this table and its results was de Moivre's hypothesis. This hypothesis was that out of every 86 persons born, one would die each year till all were dead, and that although this might not be exactly true for every individual year of age it would be true of the series as a whole. Tables which have been constructed on this hypothesis are inclined to overstate the mortality at the earlier ages of manhood, and in consequence premiums of insurance founded on this hypothesis are somewhat higher for young adult ages than they ought to be, thus causing the younger to pay for the older adults. The first table which was used to determine the amounts of insurance premiums, called Price's Northampton Table, was issued in 1762. It was not founded on a comparison of the number of deaths and the number of living at each age, but upon the deaths only. Dr Price believed that the population of Northampton at the time he constructed his table was stationary. He arrived at that belief because of the number of recorded infantile baptisms, but he omitted to note, if he was aware of the fact, that there was in that town a number of Baptists who repudiated the doctrine of infant baptism. This omission produced a grave error in the results of the table, for whereas he calculated the mean duration of life of the units of population to be 24 years, it worked out, when the omission was rectified later, at 30 years. On the original table, Government Annuity schemes were founded, in consequence of which the very same error which gave Insurance Companies premiums one-third higher than they ought to have been, caused the Government to give annuities one-third higher in value than the money payments charged warranted them to give. It was only after the Government had lost two millions sterling that the mistake was discovered and the error was rectified. The Carlisle Table by Mr Milne followed. It was based upon the observations of Dr. Heysham of the mortality of Carlisle in the years 1779–1789 and of two enumerations of its population in 1779 and 1787. Its conclusions were at first too favourable for the whole country, but they became gradually more correct later owing to increase in the mortality. From this table, De Morgan showed that of every 100 persons aged fifteen, one died each year till the age of 65 was attained. This proved to be more correct than the hypothesis of de Moivre. The table also showed that in the case of persons of the age of 10, the mean after-lifetime was 49 years, with a diminution of 7 years from that figure for every succeeding ten years above the age of 10; thus at the age of 20, the mean after-lifetime became 49–7 = 42 years; at the age of 30, 42–7 = 35; and so on.

Farr's English Life Table No. I. came next in order.[1] This was constructed on the census returns of England and Wales for 1841, and the deaths of the same year. He also issued his English Table No. II.,[2] thinking that the results of Table No. I. would be open to just criticism. Table No. II. was based on the census returns of 1831 and 1841 and the deaths of seven years—viz. 1838 to 1844 inclusive. It embraced the recorded ages of 29,810,945 persons and the registered deaths of 2,436,648 persons. Farr's English Life-Table No. III. was based on the census returns of 1841 and 1851 and on the deaths in the seventeen years, 1838–1854, numbering 6,470,720 persons. This was published as a volume in 1846. These three tables show a remarkable approximity of results, and they indicate that the mortality during these seventeen years was fairly steady, a condition which has persisted up till 1871. Farr's Healthy Districts Life Table, intended to show the results of life and death in persons most favourably circumstanced, was based on the mortality during the quinquennium 1849–1853 in 63 selected English Districts, which, during the decennium 1841–1850, showed a mean annual death-rate not exceeding 17 per 1000. The table, as Farr puts it, expresses "very accurately the actual duration of life among the clergy and other classes of the community living under favourable circumstances."[3]

Ogle's English Life Table deals with the results of the decennium 1871–1880.[4]

Tatham's English Life-Table (Manchester) is founded on the figures for 1881–1890, and his New Healthy Districts Life-Table, based on the mortality in 263 healthy Districts, gives an indication of the progress of sanitary influences in the later years of last century in favourable areas.[5]

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[1] Reg.-General's Fifth Annual Report.

[2] Reg.-General's Twelfth and Twentieth Annual Reports.

[3] Reg.-General's Thirty-third Annual Report, p. 441, *et seq.*, *Philosophical Transactions*, 1859.

[4] Reg.-General's Forty-fifth Annual Report.

[5] Supp. Reg.-General's Fifty-fifth Annual Report.

Two new Life Tables by the present Registrar-General[1] bring the facts up to the present time. One of these is based on the mean mortality of England and Wales in 1891–1900; the other, on the mortality of certain selected healthy districts during the same period. The method of constructing a life table is also described in that report.

Newsholme's Brighton Life Table is founded on the statistics for that place of the years 1881–1890.

Hayward's Life Table is based on the figures of the population of Haydock, Lancashire.

The London Life Table, prepared at the instance of the London County Council, deals also with the statistics of the area under their jurisdiction for the decade 1881–1890.

Scottish Life Tables.—The first life table of Glasgow was published in 1829 by Mr James J. Duncan. His estimate of the population was founded on the rate of increase ascertained to exist in the census years 1801, 1811, and 1821. Dr Chalmers' New Life Table for Glasgow, 1894, reproduces some of the figures from Duncan's table as well as a chart. In 1836, Mr T. R. Edmonds, B.A., wrote an article "On the Mortality of Glasgow, and on the Increasing Mortality in England."[2] This article contained data between 1821 and 1835, and he stated that the most striking fact which arose from his investigations was "The rapid and uniform increase in the mortality of adults." About 1835 Mr J. Milne contributed an article to the *Encyclopædia Britannica*[3] under the title "Mortality: Human," in which he referred to a Table of Mortality for Glasgow which he hoped to publish soon. We cannot find that it was ever published. In 1845 Neison's book on vital statistics was published. It contains a mortality table constructed for the general population of Glasgow city for comparison with the mortalities of English cities. This table was based on the census populations for 1831 and 1841, and on the bills of mortality for the city for the ten years 1832–1841. He points out as the result of his inquiry that "if the expectation of life for the city of Glasgow be referred to, the remarkable depreciation in the duration of life there will appear somewhat startling. No Table of Mortality hitherto published will show anything like so low an estimate."

Dr Chalmers published his New Life Table for Glasgow in 1894, which was based on the mortality in the decade 1881–1890.

Life Tables for the whole of Scotland have been few. The first, so far as we know, was published in 1873 by Dr W. Robertson, who was then Registrar-General for Scotland. It was based on the census of 1871, and on the registered deaths of 1873. The second, by Blair Cunynghame,[4] was based on the census population of 1891, and the deaths registered in 1890, 1891 and 1892; and the third, by Dr Crauford Dunlop,[5] on the census of 1901, and on the deaths in 1900, 1901, and 1902.

In 1904, Adams published a new life table for Scotland, which was based on the census returns of 1891 and 1901 and the deaths in the decennium 1891–1900.[1]

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[1] Supp. Reg.-General's Sixty-fifth Annual Report, 1907.

[2] *Lancet,* 1836.

[3] Seventh edition.

[4] Reg.-Gen. Scotland Thirty-eighth Report.

[5] *Ibid.,* Forty-eighth Report.

A life table ought to show the following particulars—viz.

(*a*) The probability of a unit of population living from each year of age till the next;
(*b*) The number of the living or survivors at each year of age;
(*c*) The number of the dying in each year of age;
(*d*) The mean or central population in each year;
(*e*) The aggregate number of years lived by those who survive to any given age; and
(*f*) The "expectation of life," called, also, "the mean after-lifetime," at birth and at each successive year of age.

The following table, consisting of a portion of Chalmers' Life Table for Glasgow for Males, shows the usual form and particulars of a life table.

GLASGOW LIFE TABLE

Based on the Mortality of Ten Years, 1881–1890

TABLE I.—MALES

Column	1	2	3	4	5
Age x	Dying in each Year of Age d_x	Born and Surviving at each Age l_x	Population, or Years of Life lived, in each Year of Age P_x	Years of Life lived, in and above each Year of Age Q_x	Expectation of Life at each Year of Age $E_x = \frac{Q_x}{l_x}$
0	8,950	51,234	45,870	1,802,340	35·18
1	4,348	42,284	40,051	1,756,470	41·54
2	1,856	37,936	36,996	1,716,419	45·25
3	1,122	36,080	35,514	1,679,423	46·55
4	698	34,958	34,607	1,643,909	47·03
5	542	34,260	33,988	1,609,302	46·97
6	408	33,718	33,718	1,575,314	46·72
7	310	33,310	33,155	1,541,801	46·29
8	241	33,000	32,879	1,508,646	45·72
9	200	32,759	32,659	1,475,767	45·05
*	*	*	*	*	*
103	1	1	1	1	·77

The constituency of the life table population was 51,234 males and 48,766 females, thus making up 100,000.

Since the working out of such a table is, perhaps, one of the hardest problems which a statistician has to perform, and is certainly one of the most difficult for the student of public health to follow and to comprehend, it will be well, perhaps, if the subject be treated in some detail. The headings of the above Table explain themselves; it is not so easy, however, to ascertain the mechanism. The following tables will take a step further by explaining, where such explanation is needed, the column headings, and, partly, the formulæ by which the results are arrived at.

[1] *Jour. Roy. Stat. Soc.*, vol. lxvii., part iii., 30th Sept. 1904.

SHORT LIFE TABLE

1	2	3	4	5	6
Age x	Dying in each Year of Age d_x	Born and surviving at each Age l_x	Population, or Years lived, in each Year of Age P^x	Years of Life lived in and above each Year of Age Q_x	Expectation of Life at each Year of Age $E_x=\frac{Q_x}{l_x}$
x_0	8,950	51,234	45,870	1,802,340	35·18
x_1	4,348	42,284	40,051	1,756,470	41·54
x_2	1,856	37,936	36,996	1,716,419	45·25
x_3	1,122	36,080	35,514	1,679,423	46·55
x_4	698	34,958	34,607	1,643,909	47·03
x_5	542	34,260	33,988	1,609,302	46·97
...	...	...	...	...	...
x_{103}	1	1	1	1	·77
	Actual number dying in each year of age in the series of years selected	Number of living and surviving	Mean number of the living in each year of life, or the central population	Aggregate number of years which all the persons attaining the precise age will live thereafter	Average number of years lived after any age given by average person attaining that age
	Figures in this column obtained from the death returns for series of years selected	Obtained by multiplying the number of the living at immediately preceding age by p_x $l_x \times p_x$: and $p_x=\frac{2-m_x}{2+m_x}$: and $m_x=\frac{d_x}{P_x}$.	Obtained thus: $P_x=\frac{l_x+l_{x+1}}{2}$; or as in above table: $\frac{51,234+42,284}{2}$ $=46,759$: or $\frac{42,284+37,936}{2}$	Figures obtained by adding the years in the P_x column thus: $Q_x=P^x+P_{x+1}+P_{x+2}$ $\ldots+P_{x+n}$: or $Q_x=46,759+45,870$ $+40,051\ldots\ldots$	Obtained by formula at head of table $E_x=\frac{Q_x}{l_x}$: or $\frac{1,802,340}{51,234}=35{\cdot}1$

EXPLANATORY LIFE TABLE

1	2	3	4	5	6	7	8	9
x	d_x	m_x	p_x	q_x	l_x	P_x	Q_x	$E_x=\frac{Q_x}{l_x}$
Age x	deaths at age x	Central death-rate per unit, or mortality-rate	Probability of living and completing year x	Probability of dying during the year x	Number of living during year x	Mean number of the living, or population, in each year of life	Sum of the ages from age x to end of table	Expectation of life, or mean after-lifetime
	$d_x=l_x-l_{x+1}$	$m_x=\frac{d_x}{p_x}$	$p_x=\frac{2-m_x}{2+m_x}$	$q_x=\frac{d_x}{l_x}$		$P_x=\frac{l_x+l_{x+1}}{2}$	$Q_x=P_x+P_{x+1}+P_{x+2}\ldots\ldots+P_{x+n}$	$E_x=\frac{Q_x}{l_x}$
	Obtained from death returns = number dying	Obtained from above formula	Obtained from formula	Obtained from above formula	Number living during each year of life x—*e.g.* at age x_{11} obtained thus: $l_{10}+p_{x10}$: or $l_{x+1}=l_x+p_x$	Population, or years lived, in each year of age—*e.g.* at age 21 $\frac{l_{20}+l_{21}}{2}=P_x$	Years of life lived in and above each year of age obtained by formula	Obtained by formula—*e.g.* $\frac{1,756,470}{42,284}=$ 41·54 years

Proof of formula $\underline{p_x}$:

1. Probability of living to end of year $= \frac{l_{x+1}}{l_x}$: let this probability be denoted p_x.

2. Probability of dying during the year $= \frac{d_x}{l_x}$.

3. Then $p_x = \frac{l_{x+1}}{l_x} = \frac{\text{number surviving at end of year}}{\text{number living at beginning of year}} = \frac{l_x - d_x}{l_x}$.

4. This may be expanded into $\frac{l_x - d_x}{l_x} = \frac{(l_x - \frac{1}{2}d_x) - \frac{1}{2}d_x}{(l_x - \frac{1}{2}d_x) + \frac{1}{2}d_x}$: on the assumption of a uniform distribution of deaths throughout the currency of the year. The mean population is obtained by deducting one-half of the deaths occurring in the ensuing year from the precise number living at age x.

5. Hence $l_x - \frac{1}{2}d_x$ may also be written $\frac{1}{2}(l_x + l_{x+1})$ = mean population for the year denoted $l_{x+\frac{1}{2}}$.

6. Substituting, therefore, this value in equation in (3) there becomes:

$$p_x = \frac{(l_x - \frac{1}{2}d_x) - \frac{1}{2}d_x}{(l_x - \frac{1}{2}d_x) + \frac{1}{2}d_x} = \frac{l_x + \frac{1}{2} - \frac{1}{2}d_x}{l_x + \frac{1}{2} + \frac{1}{2}d_x}.$$

7. Now, seeing that $l_x + \frac{1}{2}$ is common to both sides of this equation, divide each term by $l_x + \frac{1}{2}$, and there results:

$$p_x = \frac{1 - \frac{1}{2}\frac{d_x}{l_x + \frac{1}{2}}}{1 + \frac{1}{2}\frac{d_x}{l_x + \frac{1}{2}}}.$$ But $\frac{d_x}{l_x + \frac{1}{2}} = m_x$, or central death-rate per unit of population:

8. Therefore $p_x = \frac{1 - \frac{1}{2}m_x}{1 + \frac{1}{2}m_x}$ or $\frac{2 - m_x}{2 + m_x}$.

It is necessary, however, to go further into details in order that those steps in the construction of a life table may be followed.

The essential data in constructing such a table are (1) the number and ages of the living, and (2) the number and ages of the dying in a certain given period of time covered by years. These may be obtained or assumed in different ways:

I. An ideal method is to suppose that the fate of a million children born at the same moment of time could be observed at each year or age-period of existence until the whole million had died. This datum would give the column headed l_x, which would be the sum of the units of population which begin life simultaneously, and where l_x represents the number who reach any given precise age x. The column d_x represents the number of that population who die for any given year of life before the completion of each year of life; thus in Table I., p. 63, opposite the age one (1), the figure 4348 represents the units who died after they had completed the first year of life, but before they had completed their second year: d_x, therefore, represents the number out of l_x units who have completed the precise age x, but who have died before reaching the age $x + 1$. From this it follows that $d_x = l_x - l_{x+1}$; in other words, the number of units who die between the ages x and $x + 1$

equals the difference between the numbers living at the age x and the age $x + 1$. For example, in Table I., p. 63, the figure 51,234 in the column l_x opposite the age x_0 equals the sum of the deaths—8950—in the column d_x and the surviving lives—42,284—at the age x_1 in the column l_x.

Such a method as this, however, cannot be attained in reality.

II. A second method—a more practical one—is to trace the fate year by year of a million children born, no matter the precise dates of their births, so long as the numbers of living and the numbers of dying respectively are known for each year of life. The data for such a method are not obtainable, however, from our records. Insurance companies largely base their business on the Healthy Males Table of the Institute of Actuaries, which has been founded on the results observed of a large number of insured lives from date of insurance till death.

III. The third method, which is at once the most practical and most available method, is to operate on the data provided by a complete census of the population of a city, or combination of districts, healthy or otherwise, or, better, of a whole country, distributed according to age and sex for each year of life. Such data give the column l_x. From the annual returns of deaths, distributed in like manner for each year and covering the period of time under review, we obtain the data for the column d_x.

The method now commonly adopted is a modified form of the last-named. A considerable period of time, not less usually than a decennium, is taken, so as to neutralise any error which might result from an exceptional death-rate in any one year. The population, or sum of the lives, under consideration—the column l_x—is either obtained from the figures derived from one census enumeration, or, preferably, from two census enumerations—viz. the last, and the one immediately preceding the last census.

In such calculations it is *assumed* that the rate of mortality—*i.e.* the proportional mortality per unit of population—for any given year of life will be applicable to other units out of a given number started with at birth, and as they successively attain the year in question. When we consider that the shortest period of time dealt with in a life table is one year of life, and when it is said that a given number of units die between x year and $x + 1$ year, it is to be remembered that the incidence of deaths throughout that year is not uniform—that is, that the deaths are not equally distributed throughout the twelve months. In fact the deaths do not occur precisely at the age x, but, on the other hand, some will have happened shortly after the attainment of the age x, some during the currency of the year $x + 1$, and some just before the completion of the year $x + 1$. For purposes of a life table, however, it must be *assumed* that the deaths between age x, and the age $x + 1$ occur at equal intervals during the year, from which assumption an infinitesimal error only follows for all the years of life except the first two years. The column l_x gives the number of units out of a given assumed number born who attain any of the following precise ages; for example, in Table I., p. 63, l_4 represents the number who survive to complete the fourth year of life out of the number l_0 at birth. In the table, l_4 gives the figure 34,958, which represents the number surviving out of the population l_0, or 51,234 starting at birth. For the years l_3 and l_4, let us say, or any other two years, the number of units who attain the middle of these two or any other two years will be the arithmetical mean of the number who began the year and the number who completed it; thus: $l_x + \frac{1}{2} = \frac{1}{2}(l_x + l_{x+1})$. The number who attain the middle of the fourth year of life is $l_{3\frac{1}{2}}$ or $\frac{1}{2}(l_3 + l_4)$.

In this way the mean population, or central population, is found, which is denoted by P_x, or by L_x as it is called in actuarial works.

The deaths extracted from the registers are denoted by the column d_x. If, now, the number of deaths registered at any year of age, d_x, be divided by the mean or central population at that year of age, P_x, the rate will be obtained at which the population is dying in the middle of that year of age. This ratio of deaths to central population was denoted m_x by Farr. Actuarial writers, on the other hand, employ the term Q_x to this rate of mortality, and by the term m_x they mean the central death-rate, or the death-rate at the centre or middle of the year in question. From this is obtained the formula $\frac{d_x}{P_x} = m_x$: where m_x signifies the rate of mortality per unit of population.

Since a life table deals with the probabilities of life and death, it is necessary to see how these probabilities may be calculated from this rate of mortality m_x.

In estimating the probabilities of any given event happening, the relation of the successful to the unsuccessful events is best expressed as a vulgar fraction, of which the numerator is the number of successful or favourable events, and the denominator, the number of possible total events; thus if one puts in a bag four white balls, and twenty black balls, the total possible number of drawings of balls, taking one at a time, is twenty-four, and out of these twenty-four there will only be four drawings in which a white ball will be drawn, the remainder of the drawings being black balls; therefore, the number of possible events in which a white ball will be drawn being four, the fraction formed will be $\frac{4}{24}$: or, to put it in another way, $1 - \frac{4}{24} = \frac{20}{24}$ = the number of times in which a black ball will be drawn.

By application of this principle to the terms of a life table, let l_x equal the number of persons living at the commencement of the year x, of whom l_{x+1} survive till the completion of the year: the probability of a given unit in the series living to the end of the year is, therefore, $\frac{l_{x+1}}{l_x}$; and since the number d_x die during the year, the probability of any unit dying during the year becomes $\frac{d_x}{l_x}$. Let this probability be denoted p_x—that is, the probability that a unit of the age x will survive one full year—and the probability that the same unit will die within that year be denoted q_x, there follows this equation:

$$p_x = \frac{l_{x+1}}{l_x},$$

$$q_x = \frac{d_x}{l_x}.$$

Thus the probability of living through one year $= \dfrac{\text{number of survivors at end of year}}{\text{number living at beginning of year}} = \dfrac{l_{x+1}}{l_x} = \dfrac{l_x - d_x}{l_x} = p_x$: which may be expressed more fully in the following equation:—

$$\frac{l_x - d_x}{l_x} = \frac{(l_x - \frac{1}{2}d_x) - \frac{1}{2}d_x}{(l_x - \frac{1}{2}d_x) + \frac{1}{2}d_x}.$$

When it is assumed that the deaths in any one year, other than the first two years of life, are equally distributed throughout the year, the mean population of that year is obtained by deducting one-half the deaths occurring in the succeeding year from the exact number of units living at the age x. Hence the term $l_x - \frac{1}{2}d_x$, which is sometimes expressed $\frac{1}{2}(l_x + l_{x+1})$, equals the mean population for the year, which is denoted by $l_x + \frac{1}{2}$; therefore $p_x = \dfrac{l_x + \frac{1}{2} - \frac{1}{2}d_x}{l_x + \frac{1}{2} + \frac{1}{2}d_x}$; and, dividing each term by $l_x + \frac{1}{2}$, there is obtained the following result:—

$$p_x = \frac{1 - \dfrac{\frac{1}{2}d_x}{l_x + \frac{1}{2}}}{1 + \dfrac{\frac{1}{2}d_x}{l_x + \frac{1}{2}}}$$

but the fraction $\dfrac{d_x}{l_x + \frac{1}{2}} = \dfrac{\text{number dying at age } x}{\text{mean population at age } x} = m_x$; m_x being the rate per unit at which persons are dying in the centre of the year of age x to $x+1$, which is, moreover, the same rate as was obtained by dividing d_x of the death-registers by the p_x obtained from the census population.

Hence the following formula is evolved:—

$$p_x = \frac{1 - \frac{1}{2}m_x}{1 + \frac{1}{2}m_x} \text{ or } \frac{2 - m_x}{2 + m_x}.$$

By this formula a simple relation is found to exist between the probabilities of life and death, since after obtaining from the census returns and from the death-registers the ratio m_x for all values of x or all ages, it is easy to find p_x, and from these data we can proceed to construct a life table. The following example is taken from Table I., p. 63. The entry in the m_x column, or d_x column as it is denoted in the Glasgow Table is, as has been said, obtained by dividing the number of deaths during the year by the mean population for that year, and the probability of living one year by the formula $p_x = \dfrac{2 - m_x}{2 + m_x}$. The mean annual number of males living under one year of age during the decennium 1881–1890 was 8374·8 or 83,748, being the number of lives at risk in that decennium. The male deaths under one year, as corrected, in the same period numbered 16,030. The average annual mortality per unit for males during the first year of life was, therefore, the product of $\dfrac{16030}{83748}$—viz. 0·19141. Taking now the first part of the formula $p_x = \dfrac{1 - \frac{1}{2}m_x}{1 + \frac{1}{2}m_x}$, we get the following:—

$1-\frac{1}{2}m = 1-\left(\frac{0\cdot19141}{2}\right)=0\cdot904295$, or the population living at the end of the year, and $1+\frac{1}{2}m=1+\left(\frac{0\cdot19141}{2}\right)=1\cdot095705$, or the population living at the beginning of the year.

Hence the formula $p_x=\frac{1-\frac{1}{2}m_x}{1+\frac{1}{2}m_x}$ becomes in this case $p_x=\frac{0\cdot904295}{1\cdot095705}$ $=0\cdot82531$, or the probability for males at birth living through the first year. It is easy to show that the second part of the equation, viz. $p_x=\frac{2-m_x}{2+m_x}$, is the same as the first part by using the same figures. Reduced to terms, $p_x=\frac{2-0\cdot19141}{2+0\cdot19141}=0\cdot82531$.

The following table gives a list of the probabilities worked out for certain succeeding ages of the Glasgow Table; but the same principle is used and the same method applied to all ages until all the lives of the series have become extinct.

GLASGOW LIFE TABLE

Based on the Mortality in Ten Years, 1881–1890

TABLE II.—MALES AND FEMALES

Age	Chance of living One Year from each Age		Number surviving at each Age out of 100,000 born	
x	Males	Females	Males	Females
0	·82531	·85318	100,000	100,000
1	·89716	·90471	82,531	85,318
2	·95105	·95307	74,044	77,188
3	·96889	·97088	70,422	73,566
4	·98001	·97995	68,231	71,424
5	·98417	·98511	66,870	69,992
6	·98790	·98924	65,811	68,950
7	·99071	·99196	65,015	68,207
8	·99267	·99365	64,411	67,659
9	·99391	·99458	63,939	67,229
103	·59105	·61494	2	10

The column l_x is obtained by multiplying the number living at the immediately preceding year by p_x. Starting in the Glasgow Table with 51,234 males at birth, and having found the probability of their surviving one year, viz. 0·82531, the two are multiplied together by logarithms as the shortest method:

$$\begin{aligned}\log.\text{ of } 51{,}234 &= 4\cdot7095583\\ \log.\text{ of } 0\cdot82531 &= \bar{1}\cdot9166118\\ \hline & 4\cdot6261701 = 42{,}284.\end{aligned}$$

By thus finding the probability of life for each year or group of years, in turn, the surviving population in each year may be calculated.

The next column in the table is headed P_x. It shows the mean number living in each year of life, or, as it is designated in the table, "population of years of life lived in each year of age." The figures in this column are directly derived from the data obtained in making the column l_x. As has been seen, 51,234 males began the first year of life but only 42,284 succeeded in completing it. These 42,284 lives, therefore, contributed 42,284 years of life; but 8950 lives became extinguished during its currency; thus $42{,}284 + 8950 = 51{,}234$.

Deaths during the first year of life are, however, very unequally distributed. This will be observed by considering Table I., p. 63. It is necessary, therefore, that from the death-registers the times of death in ages of months or groups of months in the first year of life should be noted. In the Glasgow statistics they were grouped as dying under 3, between 3 and 6, and between 6 and 12 months respectively. These, however, collectively lived a certain number of years; and it was found that those 8950 infants who died during their first year of life contributed collectively 3586 years of life. These collective years of life, therefore, fall to be added to the sum of the years lived by the survivors of the first year; thus, $42{,}284 + 3586 = 45{,}870$ years, which is the first figure in the Glasgow Table under the column p_x. In the years subsequent to the first year of life, no such addition has to be made, because, as has been shown, in these years it is assumed that the deaths are equally distributed throughout the year.

The next column is the Q_x column. The number opposite any given age in the column is the sum of all the numbers in the p_x column from that age to the end of the table—that is, until all the lives have become extinct. The column shows, therefore, the aggregate years which the persons at each year of age given in the table will live; thus as in the Glasgow Table,

$$Q_x = P_0 + P_1 + P_2 + P_3 + P_4 + P_5 + P_6 + P_7 + P_8 + P_9 + \ldots\ldots P_{103}$$

The figures in the last column $E_x = \frac{Q_x}{l_x}$, that is, the expectation of life at each year of age, or, as it is also called, the mean after-lifetime, are obtained by dividing the figure in the column Q_x by the opposing figure in the column l_x; thus, $1{,}756{,}470 \div 40{,}051 = 41{\cdot}54$; and the next succeeding figure in the column is less than that immediately above it by the figure in the P_x column; thus: $1{,}756{,}470 - 40{,}051 = 1{,}716{,}419$.

It must be observed that in all that has been said up till now it has been assumed that the numbers of population and of deaths for each sex at each age are known. This, however, is not possible in practice, for in the census returns and the annual death returns the figures are given only for groups of ages. The figures for intermediate ages in age-groups must, therefore, be obtained by interpolation, which is specially applicable to the later years of life, but is not suitable for the first five years of life.

The Glasgow Life Table, from which we have in the main taken our examples, was based on the census returns of 1881 and 1891, and on the deaths recorded during the ten years 1881–1890. In constructing the table it was necessary to have the following accurate data, viz. (1) the population for each year of age, and (2) the number of deaths occurring during each corresponding year of age, so that the exact death-rate for each year of age might be exactly ascertained. These data, as has been remarked, are not supplied by the census returns either for yearly population in each age or for yearly deaths in each year of life. The first thing necessary to be done, therefore, is to sort out the total population into age-groups for each sex, and then the deaths according to age as follows :—0–1, 1–2, 2–3, 3–4, 4–5, 5–10, 10–15, 15–20, 20–25, 25–35, 35–45, 45–55, 55–65, 65–75, 75–85, 85–95, 95 and upwards. These populations, it must be noted, are the populations for 1881 and 1891 respectively as enumerated at the end of March —the end of the first quarter of the year. It is necessary, therefore, to obtain the mean or central population in the middle of the year by geometrical progression as in finding intercensal populations.

Farr in his Life Table No. III. pointed out that "the true mean population, which, multiplied by the number of years in the period, is equal to the years of life in it, is less than the mean of the population living at the beginning and end of the period, and more than the population living in the middle of the period." To correct this, Tatham in his Manchester Life Table used the following formula :—

$$\frac{PR - P \times \cdot 43429448}{\text{Common log. of R}}\,;$$

where *PR* represents the population to be sought and *P* the population at some previous time. This gives the exact mean number living at all ages throughout the decade, which works out in the Glasgow Table as 536,810 persons, instead of 537,266, which is the arithmetical mean. Knowing the number of male and female deaths during the decade for all ages, it is now easy to find the average annual death-rate per unit of population during the decade, thus :

$$\frac{\overset{\text{Male Deaths}}{65{,}553} \quad + \quad \overset{\text{Female Deaths}}{64{,}994}}{\underset{\text{(Pop. during 10 Years)}}{5{,}368{,}100}} = \cdot 024319 \text{ per unit;}$$

or 24·32 per 1000 per annum of those living.

From the mean number living the number of lives at risk during the decennium is ascertained by multiplying the number living by the number of years in the period—viz. 5,368,100 ; and these estimated numbers may now be subdivided into various age-groups.

From the numbers of lives at risk in the various age-groups and the numbers of deaths at the corresponding ages, the annual death-rate for each group may then be calculated.

The construction of that part of a Life Table which deals with the first quinquennium of life always presents special difficulties, because the figures of population in these years, although they are published in the census returns, are very untrustworthy, and because the method of interpolation is unsuitable. Recourse must, therefore, be had to the birth and death statistics of such children.

The number of deaths in the Glasgow Table of male children under five years was 30,836, and the mean population for the group of years 0–5 was 35,753·6, which gives an average annual mortality-rate per unit of ·8624, or 86·24 per 1000 living. But it was found that of the

30,836 deaths, 16,030 occurred in children under one year, 7933 between the ages 1–2, 3450 between 2–3, 2106 between 3–4, and 1317 between 4 and 5 years. To obtain the numbers living at these ages, such can only be obtained by finding (1) the numbers of deaths registered at each of these individual years of life, and (2) the number of births registered annually for the series of years. In Glasgow, in the decennium 1881–1890, 100,661 male children were born, and during the same decennium 16,030 male infants died during the age 0–1. It is clear that a certain number of these 16,030 deaths registered in 1881–1890 would be of children who were born during the currency of the year 1880, and in like manner some of the male infant deaths under one year which were registered in the early months of 1891 would be of children born during the currency of 1890. The constituency of children, therefore, from which the deaths in any year are contributed must necessarily, on the assumption that the deaths are uniformly distributed throughout the year, include, in the above case, one-half of the children born during the year 1880, and not include one-half of the children born in 1890; in other words, in the decennium 1881–1890, one-half of the children born during 1880 must be added to, and one-half of those born in 1890 must be subtracted from, the total infant population born in that decennium, in order that the number out of which the deaths under one year of age occurred in 1881–1890 may be obtained, thus:

	Total male births,		1881–1890	=	100,649
plus	One-half	,,	1880	=	4,822·5
					105,471·5
less	One-half	,,	1890		4,931
					100,540·5

which is the total number of male infants born from which 16,030 deaths under one year occurred in the decennium.

To obtain the number of males living out of which the deaths in 1881 under two years occurred, the constituency consists of:

One-half the male births of 1879
All the ,, ,, of 1880 to 1888; and
One-half the ,, ,, of 1889.

From the total so obtained, the deaths of males under one year occurring in 1881–1890 fall to be deducted. To obtain the numbers of males between four and five years out of which the deaths during these ages occurred, the constituency will consist of:

One-half the male births of 1875
All the ,, ,, of 1876 to 1886 inclusive; and
One-half the ,, ,, of 1887;

and from the sum of these must be deducted the deaths under 1 year occurring in 1877–1886, those under 2 years occurring in 1878–1887, those under 3 years occurring in 1879–1888, and those under 4 years occurring in 1880–1889.

But it has also to be noted that the mean annual population of male children under 5 years, as calculated from the census returns, was 35,753, and that this figure is much less than the number which would have been found if that population of male children had only been disturbed or reduced by death. The difference falls to be explained by the emigration of families in which there were male children under 5 years of age. These numbers in deficiency must also be dealt with in a table, and, proportioned by the differences, must be allocated to the male population of the years 0–1, 1–2, 2–3, 3–4.

After these corrections have been duly made, the exact numbers of population for each year under 5 are arrived at, out of which the respective yearly deaths occur.

In the construction of the New English Life Table for 1891–1900,[1] the scheme of interpolation for ages over 5 years which was employed was to take the values of log. p_x at ages 5, 15, 25, etc., in groups of five, beginning successively at ages 5, 15, etc., each series thus covering a period of forty years. The interpolated values for the middle twenty years of each series were only used on the principle that the values near the centre of a series will be nearer the truth than those at the end of the series. By this means two values of log. p_x were obtained at a particular age.

Conditions to be observed in all Statistical Calculations:—

Quetelet's rules are well worthy of remembrance in all statistical investigations. These are:

1. Not to have preconceived ideas as to what figures are to prove;
2. Never to reject any figure that appears contrary to one's expectation;
3. Carefully record and consider all possible causes of an event, and do not accord to one cause what is actually the result of several causes in combination;
4. Never compare data which have nothing in common.

To observe the foregoing rules and to sustain statistical conclusions on the high and exact standard worthy of statistics, the following observances must be rigidly followed—viz.

1. Facts, or numerical units, must be exactly comparable. As Parkes puts it, "the dividing character must be so definite as to leave no doubt into which group a unit shall fall; it must be precise enough to prevent the possibility of a unit being in two groups at the same time."

2. The facts, or numerical units, must be arranged into groups, and a constant numerical standard must be adopted to show the relation of the groups to the units. This standard may be per 100, 1000, or 1,000,000.

3. The smaller the number of facts from which certain conclusions are inferred [the process being *in*duction not *de*duction], the greater the liability to probable error; and the converse is true. The *probable error* has been well defined as "the amount of departure from the average within which, on one side or other, it is an even chance that the truth exists." In all calculations derived from small numbers, therefore, while they are true of that set of acts, they must not be taken as true of the next series of facts; in other words, variation exists, which variation is the probable error. This will be better illustrated by concrete examples. We speak, for example, of the "average" or "mean" death-rate. For instance, in the decade 1871–1880 the mean death-rate was 28·09 per 1000 of the population, and by that is meant that the sum of the death-rates of the years 1871

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[1] Supplement to Sixty-fifth Annual Report of the Registrar-General, 1907.

to 1880 inclusive divided by ten, the number of years, was 28·09 ; but in that series of figures each was different. *The mean or average, therefore, is obtained by dividing the sum of the facts by the number of them.* This is called the *Arithmetical Mean* or *Average.* The following is a worked-out example :—

Table XXIII.

Death-Rates of Glasgow, 1898–1907

Year		Death-Rate per 1000 per Annum
1898	=	21·2
1899	=	21·6
1900	=	22·0
1901	=	21·2
1902	=	20·0
1903	=	19·0
1904	=	19·3
1905	=	17·9
1906	=	17·8
1907	=	18·5

198·5 ÷ 10 = 19·85 = mean of whole series.

It will be observed, however, that in that series of figures some of the figures are above and some below the mean, or average. Therefore, it would not be correct to say that 19·85 will be the true death-rate of the next decennial period, but only approximately true. The relation of this arithmetical mean to the series of facts from which it is obtained is such that the differences of the mean of the numbers greater than the mean from which the mean of the whole series is subtracted, and of the mean of the numbers less than the mean subtracted from the mean of the whole series, exactly neutralise or are equal to one another. Thus :

Death-Rates greater than the Mean of Whole Series—19·85

1898 = 21·2
1899 = 21·6
1900 = 22·0
1901 = 21·2
1902 = 20·0 = 106·0 ÷ 5 = 21·2

Death-Rates less than the Mean of Whole Series

1903 = 19·0
1904 = 19·3
1905 = 17·9
1906 = 17·8
1907 = 18·5 = 92·5 ÷ 5 = 18·50

21·2 − 19·85 = 1·35 = error in excess ;
19·85 − 18·50 = 1·35 = error in deficiency ;
1·35 + 1·35 ÷ 2 = 1·35 = mean error ;
1·35 × 0·6475 = 0·91 = probable error.

Therefore in the next decennial series the death-rate might be :

$$\left.\begin{array}{lcl} 19{\cdot}85 + 0{\cdot}91 & = & 20{\cdot}76 \\ \text{or } 19{\cdot}85 - 0{\cdot}91 & = & 18{\cdot}94 \end{array}\right\} \text{ per 1000 per annum.}$$

To find the mean error : (1) find the mean of the series of observations ;

(2) find the mean of the observations above the mean of the whole, and subtract the mean from it, which will be the mean error in excess; (3) find the mean of the observations below the mean of the whole, and subtract it from the mean, which will be the mean error in deficiency; (4) add the two quantities, and take the half; and the answer will be the mean error; the *probable* error is 0·6745 or roughly $\frac{2}{3}$ of the mean error.

Another method of estimating the probable error is Radicke's "Method of Successive Means."[1] The method may be demonstrated from the same figures.

First Mean $21{\cdot}2$
Second Mean $=21{\cdot}2+21{\cdot}6\div2=$ $21{\cdot}4$
Third Mean $=21{\cdot}2+21{\cdot}6+22{\cdot}0=$ $21{\cdot}6$
Fourth Mean $=21{\cdot}2+21{\cdot}6+22{\cdot}0+21{\cdot}2=$ $21{\cdot}5$
Fifth Mean $=21{\cdot}2+21{\cdot}6+22{\cdot}0+21{\cdot}2+20{\cdot}0=$ $21{\cdot}2$
Sixth Mean $=21{\cdot}2+21{\cdot}6+22{\cdot}0+21{\cdot}2+20{\cdot}0+19{\cdot}0=$ $20{\cdot}8\dot{3}$
Seventh Mean $=21{\cdot}2+21{\cdot}6+22{\cdot}0+21{\cdot}2+20{\cdot}0+19{\cdot}0+19{\cdot}3+$ $20{\cdot}614$
Eighth Mean $=21{\cdot}2+21{\cdot}6+22{\cdot}0+21{\cdot}2+20{\cdot}0+19{\cdot}0+19{\cdot}3+17{\cdot}9$ $20{\cdot}270$
Ninth Mean $=21{\cdot}2+21{\cdot}6+22{\cdot}0+21{\cdot}2+20{\cdot}0+19{\cdot}0+19{\cdot}3+17{\cdot}9+17{\cdot}8=20.$
Tenth Mean $=19{\cdot}85$
$=208{\cdot}469\div10=20{\cdot}47=$mean of the ten means.

From the foregoing set of means it will be seen that it is only in the last five that the figure 20 is common, and that they approach the arithmetical mean or average.

Radicke also advises, in order that the truth may be still more nearly approached, the employment of the Quadratic Mean, which is the square root of the arithmetical mean of the squares of the given numbers.

In addition to the arithmetical and successive means, there are the geometric, harmonic, and quadratic means, which, however, are hardly ever used in practice for statistical calculations. The reader is referred to the monograph by Radicke for fuller information (*loc. cit.*). The bases of the methods by which these means may be arrived at may, however, be set down.

Suppose it is required to ascertain the mean of the following four numbers, 6, 8, 9, 3, by these different means. Then, the *arithmetical mean* is obtained by dividing the sum of the observations by the number of them, thus:

$$\frac{6+8+9+3}{4}=6{\cdot}5$$

The method of *successive means* is obtained by taking the mean of the first two numbers, then of the first three, then of the first four, and so on until the series of observations is exhausted. The accuracy or inaccuracy of the mean is exhibited by the concurrence or non-concurrence of the figures of the different means obtained, results which depend upon the largeness or smallness of the number of observations. In our example there can be no pretence to accuracy.

$$\frac{6+8}{2}=7$$

$$\frac{6+8+9}{3}=7{\cdot}6$$

$$\frac{6+8+9+3}{4}=6{\cdot}5$$

The *geometric mean* is the product of the figures of the observations multiplied together into the root of the number of observations, thus:

$$\sqrt[4]{6\times8\times9\times3}=\sqrt[4]{1296}=6.$$

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[1] *New Sydenham Soc.*, vol. xi. p. 1861. "On the Importance and Value of Arithmetical Means."

The *harmonic mean* is the "reciprocal value of the arithmetical mean of the reciprocal values of the given numbers." The reciprocal value of any number is that number used as the divisor of unity; thus the reciprocal value of $6=\frac{1}{6}$, of $9=\frac{1}{9}$, of $8=\frac{1}{8}$, and so on. In the above case, it works out thus:

$$\frac{\frac{1}{6}+\frac{1}{8}+\frac{1}{9}+\frac{1}{3}}{4}=\frac{\frac{954}{1296}}{4}=\frac{238\frac{1}{2}}{\underline{1296}}=\frac{1296}{238\frac{1}{2}}=\underline{5{\cdot}4339}.$$

The *quadratic mean* is the square root of the arithmetic mean of the squares of the given numbers, thus:

$$\sqrt{\frac{6^2+8^2+9^2+3^2}{4}}=\sqrt{\frac{190}{4}}=\sqrt{47{\cdot}5}=\underline{6{\cdot}89}.$$

It will be observed that the means of the figures above given are different from each other. They are respectively:

Arithmetic mean $=6{\cdot}5$.
Method of successive means = a figure which is derived from too small a number of observations to pretend to any value to accuracy.
The geometric mean $=6\cdot$
The harmonic mean $=5{\cdot}4439$.
The quadratic mean $=6{\cdot}89$.

According to Radicke the quadratic always exceeds the arithmetic mean, depending upon the greater inequality of the numbers: the more equal the numbers the greater the coincidence.

The arithmetical mean may be used in different sets of circumstances—viz.

First, as the expression of a pure average, where it is applied to numbers which are exact and definite. It may be applied to ages of a body of individuals or to any other definite sets of ascertained facts. Ten persons, for example, are aged respectively 2, 6, 8, 10, 20, 60, 65, 80, 84, 91. The average age of the group will therefore be 42·6 years, on the supposition that the surplus of years of the seniors could be transferred to the juniors. In another group of ten, however, the average works out as 36. All that may legitimately be inferred from these facts is that the aggregate of ages of these two groups has the relation of 42·6 and 36.

Second, as the expression of the probable value of a definite fixed quantity. This method may be applied to a series of measurements of an object, a series of chemical analyses of a given fluid, or such like problems in which errors originating in the observer are likely to arise.

Third, as the expression of the probable value of a variable quantity estimated under mean conditions. Most statistical calculations are of this nature, and being liable to probable error from different factors must be corrected or subjected to corrections against probable error.

It may be taken as the expression of a general truth that the less the difference between an average and the individual figures of a series from which such average so obtained, the greater the value of the average in that it approximates more closely to the truth.

The best method of arriving at the probable error in cases where a series of facts is divided into two sub-component groups is by *Poisson's Rule* or *Formula*, which may be thus expressed:

Let μ be the total cases in the series;
,, m be the number in one sub-component group;
,, n be the number in the other sub-component group.

The proportion of each group to the whole series will be, respectively, $\frac{m}{\mu}$ and $\frac{n}{\mu}$; but these proportions will vary within certain limits in succeeding instances, and the extent of the variation will be within the proportions represented by the following mathematical expressions :—

$$\frac{m}{\mu} + 2\sqrt{\frac{2.\ m.\ n}{\mu_3}}\ ;\ \text{and}$$

$$\frac{m}{\mu} - 2\sqrt{\frac{2.\ m.\ n}{\mu_3}}\ .$$

Obviously, the larger the value of μ the less will be the value of $\sqrt{\frac{2.\ m.\ n}{\mu_3}}$, and consequently the less will be the limits of error in the simple proportion of $\frac{m}{\mu}$; and the converse is true.

Gavarret,[1] quoted by Parkes, takes an example from Louis' work on Typhoid Fever, in which Louis tries to determine the effect of remedies by adducing the number of recoveries and deaths in a series of cases of that disease. The series comprised 140 cases, with 52 deaths and 88 recoveries, and the question arose, What is the percentage mortality, and how near is it to the true proportion ? The percentage mortality in that series was 37·143. How near is this percentage to the truth ?

The probable error is worked as follows :—

Let μ =140 =the total number of cases.
,, m = 88 =the number of recoveries.
,, n = 52 =the number of deaths.

$$\text{then, } 2\sqrt{\frac{2\times 52\times 88}{140_3}} = 2\sqrt{\frac{9152}{2744000}} = 2\sqrt{\cdot 00331} = \cdot 05771\times 2 = \cdot 115420$$

to unity ; or 11,550 in 100,000 cases.

The mortality being 37·143 per cent. in that series, or 37,143 deaths in 100,000 cases, by the first part of the formula it may either be 37·143 + 11·550 = 48·693 per cent., or 48,693 in the next 100,000 cases, or by the second part of the formula, 37·143 – 11,550 =25·593 per cent., or 25,593 in the next 100,000 cases ; in other words, in another series of the same number—140—the percentage mortality will range from nearly 49 per cent. to nearly 26 per cent. The range of probable error, therefore, is very great from such a small number of observations, and the percentage mortality of this series of little or no value in forecasting the mortality of the next. Newsholme demonstrates[2] by this formula the statement that the smaller number of data from which a calculation is made the greater the probable error. He puts it thus : If out of ten cases of cholera seven recover, how near is this to the true average rate of recovery ? What will be the possible variation in 100,000 cases on this basis ?

$$2\sqrt{\frac{2\times 7\times 3}{10_3}} = 2\sqrt{\frac{42}{1000}} = \cdot 40980 \text{ to unity, or 40,980 to 100,000 cases,}$$

that is, 70 + 40·98 =110·98 per cent., or 110·98 in 100,000 cases, which is absurd,
or 70 – 40·98 =29·02 per cent., or 29,020 in 100,000 cases.

If the number of cases be raised to 100, the other ratios remaining the same. the error falls to as ·13 is to unity ; in other words, in 100,000 cases, the recovery-rate may be either 83,000 or 57,000. Raising the number of cases to 1000, other things equal, the error further falls to as ·04 is to unity ; so that in 100,000 cases the number of recoveries may be either 74,000 or 66,000. When we come to a million cases, the error sinks into insignificance, being only as ·0013 is to unity ; for in 100,000 cases the number of recoveries may be either 70,130 or 69,870, which is practically the truth.

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[1] *Statistique Médicale*, 1840, p. 284.

[2] *Op. cit.*, 1st ed., p. 295.

It ought to be remembered that the percentage expression of a result from a series of accurately observed data is an accurate expression of the truth with respect to that series only, and is only approximately near the truth as an expression of the result in the next or other series of cases ; therefore, for purposes of comparison, or as a forecast, it is only approximately correct. Statistical fallacies mostly arise from trying to compare incomparable things, and from imperfect constitution of groups. As an example of the former may be taken the common fact of instituting comparisons of the healthiness of two districts from their death-rates. While, although every care may be exercised on all points to make the comparison as equal as it can be made and the fallacy may not be serious, it nevertheless still exists. Another fallacy is involved in the comparison of the number of deaths from any given disease in two different years of a population, unless due allowance is made for the altered incidence of population in the interval. Further, fallacy is often involved in the attempt to arrive at the mean death-rate of a county, for example, by taking the mean of the separate rates returned for different districts. Say, for example, that the death-rate of District A, with a population of 15,000, is 24 per 1000 ; that of District B, with a population of 18,000, 22 per 1000 ; that of District C, with a population of 22,000, 26 per 1000 ; it would be incorrect to conclude that the average death-rate was 24 + 22 + 26 ÷ 3 = 24 per 1000. The problem of ascertaining the true average is worked out as follows :—

Population of A = 15,000
Population of B = 18,000
Population of C = 22,000

Total population = 55,000

$$\left(\frac{15,000}{55,000} \times 24\right) + \left(\frac{18,000}{55,000} \times 22\right) + \left(\frac{22,000}{55,000} \times 26\right) = \left(\frac{15}{55} \times 24\right) + \left(\frac{18}{55} \times 22\right) + \left(\frac{22}{55} \times 26\right)$$
$$= \frac{360 + 396 + 572}{55} = 24{\cdot}8 = \text{average death-rate.}$$

If the death-rates for Districts A, B, C had, however, been 24, 12 and 26 respectively, the other factors remaining the same, the death-rate by the former method would have been 20·67, whereas, properly calculated, it would have worked out as 20·48. It will easily be seen, where the figures in the problem diverge more widely, how much greater the error is likely to be.

There are certain terms used in statistics the meaning of which ought to be clearly comprehended.

Mean age at death is the average age at which death occurs in a mixed population, and is the figure obtained by dividing the sum of the ages of persons who die in the year by the number of deaths.

$$\frac{\text{Sum of Ages at Death}}{\text{Number of Death}} = \text{Mean Age at Death.}$$

Mean Duration of Life, or *Expectation of Life at Birth, in a stationary population* means exactly the same thing as the *mean age at death*; but in a progressive population they differ considerably. In England and Wales, for example, in 1881–1890 the mean duration of life for males was 43·66 years, whereas the mean age at death was 29 years. In progressive populations, therefore, the mean duration of life is found from life tables, which represent the life progress of a generation of a million from birth to death. In Farr's Life Table No. III., which was based upon the census returns of 1841 and 1851 and upon six million odd deaths registered from 1838–1854 inclusive, the mean age at death is 40·9 years, which was equivalent to the mean after-lifetime, and the population in the table became reduced to one-half in 45 years, which, therefore, was the *probable lifetime.* In the absence of life tables, which, however, are the most accurate methods of ascertaining such statistical data as the foregoing, *Willich's formula* for ages between 25 and 75 serves the purpose approximately—viz.

$$x = \frac{2}{3}(80 - a)\text{; where } x = \text{expectation of life;}$$

$$a = \text{age of individual.}$$

Thus by this formula the expectation of life of a person aged 30 would be:

$$x = \frac{2}{3}(80 - 30) = 33{\cdot}3 \text{ years.}$$

Farr's formula may also be used, where the birth- and death-rates of a community over a long period are known—viz.

$$\left(\frac{2}{3} \times \frac{1}{d}\right) + \left(\frac{1}{3} \times \frac{1}{b}\right)$$

where $d =$ death-rate, and $b =$ birth-rate.

If the average death-rate of a community in 1891–1892 was 20 per 1000, or ·02 per unit, and the birth-rate 34 per 1000, or ·034 per unit, what would be the expectation of life?

Reduced to terms the equation is as follows:—

$$\left(\frac{2}{3} \times \frac{1}{\cdot 02}\right) + \left(\frac{1}{3} \times \frac{1}{\cdot 034}\right) = 33{\cdot}\dot{3} + 9{\cdot}804 = 43{\cdot}104 \text{ years.}$$

Bristowe's formula is sometimes used for the same purpose in an increasing population—viz.

$$x = \frac{\log.\ b - \log.\ d}{\log.\ (1 + r)}\text{;}$$

where $x =$ mean duration of life; $b =$ birth-rate per unit of population; $d =$ death-rate per unit of population; and $r = b - d =$ increase per unit per annum.

There are certain other expressions used in statistics with the precise meaning of which the student ought to be familiar, such as *Mean Age at Death, Probable Duration of Life, Mean Expectation of Life at Birth, Life Capital,* and *Specific Intensity of Life.*

Mean Age at Death is arrived at by dividing the sum of the ages of the units of population who die in a year by the number of deaths, thus :

$$\text{Mean Age at Death} = \frac{\text{Sum of Ages of Units of Population at Death}}{\text{Number of Deaths}}.$$

Probable Duration of Life, sometimes called the Equation of Life, is the age at which any number of children born will be reduced to one-half by death. It is found by a life table. In the English Life Table for 1871–1880, a million male children born would be reduced to half-a-million in the forty-eighth year, in the Life Table for 1881–1890, not until the fifty-second year, and in the Table for 1891–1900 not until the fifty-third year of life, whereas in these three tables respectively the figures for a million female children born were the fifty-third, fifty-seventh and fifty-eighth year respectively.

Mean Expectation of Life, or Average Lifetime, at Birth, is the number of years after birth which an average child of a series may be expected to live. These figures are found by a life table. In the three aforementioned English tables the expectation at birth for male children was found to be 44·62, 47·18, and 47·77 years respectively.

TABLE XXIV

Expectation of Life of Males at Birth

London Life Table (London, 1891–1900)	=40·98 years.
Brighton Life Table (Brighton, 1881–1890)	=43·59 years.
Glasgow Life Table (Glasgow, 1881–1890)	=35·18 years.
Manchester Life Table (Manchester, 1881–1890)	=34·71 years.
Haydock (Lancs.) (Haydock, 1891–1900)	=42·42 years.

Life Capital is a term intended to express the sum of the products obtained by multiplying the population of each age-group by the mean expectation of life for each age-group.

Specific Intensity of Life is a term used to represent the product of the number living at any age divided by the number of dying at the same age ; thus, supposing that out of 100,000 born 70,000 reach the age of 40, and that of those 860 die during that year of age, then $\frac{70{,}000}{860} = 81{\cdot}4 =$ specific intensity.

STATISTICAL TESTS BY WHICH THE HEALTH CONDITIONS OF A COMMUNITY MAY BE GAUGED

The following are probably the best tests—viz.

First.—The Corrected Death-Rate, where the population is fairly large and not liable to sudden fluctuations one way or other, and in the absence of unusual epidemics ;

Second.—The Rate of Infantile Mortality, which is an index of the conditions of life of children, or of occupations of the mothers ;

Third.—The Zymotic Death-Rate. While this is liable to fluctuations due to causes somewhat outside the control of a sanitary department, a high rate may be taken as indicative of insanitary conditions ;

Fourth.—The Respiratory Diseases Death-Rate indicates either unhealthy climatic conditions, smoky irritating atmosphere, or unhealthy occupations or conditions of home-life, or some of these combined ;

Fifth.—The Phthisis Death-Rate is also indicative of the same general conditions.

CHAPTER III

METEOROLOGY

A well-ordered annual report cannot be considered complete without furnishing information respecting certain meteorological data. Of these, the following are of the first importance—viz.

I. Temperature; II. Atmospheric Humidity; III. Rainfall; IV. Barometric Pressure. To each of these some brief attention must be given.

Temperature.—A record of temperature ought to be taken at least night and morning at different stations, as well as a record of the mean and extreme temperatures. Temperature may be considered in relation to its changes in *space* and in *time*. The changes or differences of temperature in *space* bring in the whole question of climatology, while those in *time* deal only with periodic variations, either hourly, daily, seasonally, or annually. It is with this last feature that the health officer has chiefly to deal. Extremes of temperature are simply indicated by the highest and lowest readings of the thermometer which may occur in any given place during any given period; thus there are diurnal as well as seasonal extremes. The readings of such temperatures are recorded by thermometers in the shade as well as by those in the open. Of the former there is a maximum and a minimum instrument, and in use these are protected from radiation by a louvred screen, their height being four feet from the ground-level.

Maximum Thermometer.—The maximum instrument consists of a mercurial column the index of which is formed by a smaller column of mercury separated from the main column by a minute bubble of air, by the expansion of which the index is pushed forward to its furthest point, but which does not recede when the air contracts; hence the end of the index furthest from the bulb of the instrument indicates the highest temperature recorded during the day of observation. When setting the instrument for use it must be swung briskly with the bulb downwards, so as to cause the mercurial index-column to recede to a low reading. When set, it should be placed in a horizontal position.

Minimum Thermometer.—There are two kinds in use, that of Casella, which is filled with mercury, and that of Rutherford, with spirit. The former, because of the difficulty experienced in its manipulation, is seldom used. In the latter the index is immersed in spirit. When about to be used, the index is permitted to run down to the end of the column by simply sloping the instrument with the bulb uppermost; it is then placed in its horizontal position. Should the temperature rise, the spirit simply flows past the index leaving it undisturbed, but should it fall, the index recedes with the spirit, and so records the lowest reading within the time for which it has been set. This instrument is liable to the serious objection that a portion of the spirit may evaporate from the bulb and condense in the upper part of the column of the instrument. There is, however, one instrument which records at the same time both the maximum and the minimum temperature. It is a spirit thermometer, the tube of which is bent on itself —parallel-wise—with a bulb at each end, one bulb being larger than the other. Each bulb is filled with spirit, but the smaller one contains also a bubble of air. The bend of the tube is filled with mercury, and the registration is accomplished by two indices which consist of steel pins seated in glass tubes, having hairs attached to the tubes to keep them in any position to which they may have been pushed by the mercury column, or by the steel magnet employed to set them. To set the instrument, the steel indices by means of the small magnet are brought down to rest on the top of the mercurial column. When the temperature rises, expansion takes place in the spirit in the larger bulb and pushes the mercury and index before it, which latter remains at the highest or furthest point attained. When the temperature falls, the spirit contracts, and the pressure of the bubble of air in the smaller bulb propels the mercurial column back and so moves the minimum index to its lowest reading. This instrument is kept in a vertical position.

The thermometers used in the open are also a *maximum* and *minimum*; the former indicating the highest temperature in the sun, the latter, the lowest. The former has a blackened bulb *in vacuo* and is placed in position on forked sticks about four feet above the ground. The minimum instrument possesses a clear bulb.

The term "mean temperature" is one which is frequently employed in connection with health-resorts, and in meteorological reports. If hourly thermometric observations are made, the mean is approximately the sum of the twenty-four readings divided by that figure. But the term is also used with reference to months, a year, or a series of years. While, however, the mean daily temperature may be approximately determined as described, the result is not actually correct. A formula has been constructed by Kaentz, modified by Lloyd, to arrive at the correct mean—viz.

Min. reading $+$ (Max. reading $-$ Min. reading) $\times$ co-eff. a $=$ Mean Temperature.
For example: Max. temp. on a given date $= 54{\cdot}2°$ F.,
Min. ,, ,, same ,, $= 41{\cdot}4°$ F.,
$\therefore\ 41{\cdot}4 + \{54{\cdot}2 - 41{\cdot}4 \times {\cdot}41\} =$
$41{\cdot}4 + \{12{\cdot}8 \times {\cdot}41\} =$
$41{\cdot}4 + 5{\cdot}25 = 46{\cdot}65°$ $=$ Mean Temperature.

The mean annual temperature of any given place is practically of little value. For example, the mean annual temperature of Dublin is 49·3° F., and that of New Haven in Connecticut, 49·2° F., but the climates of these two places are very different. In January, the mean temperature of Dublin is 40·6° F., while in the same month that of New Haven is 26·6° F., ; in July, that of the former place is 59·7° F., while that of the latter is 71·6° F. The difference, therefore, between the coldest and the hottest months is for Dublin only 19·1° F., while for New Haven it is 45° F. Again, the mean annual temperature of St

Louis is 53·96° F., and of Algiers, 55·76° F., but the summer temperature of the former place is 74·84° F., and the winter temperature is 32·9° F., while the temperatures of Algiers for these respective seasons are 73·94° F., and 53·96° F. The mean annual temperature of places, therefore, of itself gives no information as to the annual range of temperature, except where the places are situated in the same kind of climate, insular or continental.

The temperature of the air depends upon (1) altitude, (2) latitude, (3) distance from the sea, (4) temperature of the sea, and (5) exposure. Of these, probably the two most important are altitude and latitude. The mean temperature falls about 5·5° C. for each 1000 metres of ascent, or 16° F. per mile. In the northern hemisphere between 30° and 70° N. the mean temperature decreases only 0·75° C., or 1·35° F., for each increase of one degree of latitude, or, in other words, 0·0068° C. for every kilometre, or 0·0197° F., for every mile nearer the Pole.

Mean temperature varies greatly from day to day, less from month to month, and still less from year to year. The rise or fall of temperature in degrees centigrade for every 100 metres of ascent has been observed on the Eiffel Tower in Paris and in the observatories on Ben Nevis. Taking the mean of twenty-four hours, in the case of the former it was found to be in winter – 0·13°, in spring – 0·15°, in summer – 0·50°, and in autumn – 0·14°, and throughout the year – 0·32° C. ; in the case of the latter, it was found to be for the corresponding periods – 0·60°, – 0·72°, – 0·68°, – 0·63°, and – 0·66° C.

An *isotherm* is a line denoting equal temperature. An isothermal map is the map of an area of differing extent which shows lines—these may be curved lines—of equality of temperature over a given period of time. They must be looked upon only as approximations to correctness regarding the superficial distribution of temperature, the level in all observations being sea-level.

To find the actual mean temperature—monthly or annual—of any place crossed by an isotherm, subtract the height of the place in metres by 150 or 200, as the case may be, from the value of the isotherm in degrees centigrade, or the height in feet divided by 270 or 365 from the value of the isotherm in degrees Fahrenheit; by 150 where the vertical gradient averages 1° C. for every 150 metres, by 200 where that gradient averages 1° C. for every 200 metres, and by 270 or 365 respectively where the vertical gradient averages 1° F. for every 270 or 365 feet respectively.

If, for example, a place 250 metres in height lies between the isotherms 10° C. and 12·5° C., so that its mean sea-level temperature is indicated by 10·5° C., then its actual mean temperature is

$$10{\cdot}5^\circ\ \text{C.} - \frac{250}{200} = 9{\cdot}25^\circ\ \text{C.},$$

if the decrease of temperature due to height be taken as 1° C. for 200 metres; or, if the height of the place be 820 feet above sea-level, and if it lie between isotherms 50° F. and 55° F., its mean sea-level temperature being indicated as 50·9° F., and if the decrease of temperature due to height be taken as 1° F. for 270 feet, then its actual mean temperature is

$$50{\cdot}9^\circ\ \text{F.} - \frac{820}{270} = 47{\cdot}9^\circ\ \text{F.}$$

Isotherms of British Islands.—These have been based on the mean temperature of 400 meteorological stations reduced to a forty-year period, 1856–1895.

These isotherms have been found to follow an east-and-west course, which indicates that the sun is the chief influence which determines the annual distribution of temperature. If a line be drawn from Southampton northwards through the central districts of England, the distances between each isotherm are not very variable in extent. But in Scotland there is a greater distance than the average between the isotherms of 48° F. and 47° F. (8·9° C. and 8·3° C.). The greatest differences of distance between the isotherms are where they are cut by the line of longitude 4° W. These distances from Dorsetshire to Cromarty are 92, 155, 56, 58, and 184 miles respectively. These disturbances here indicate the influence of the ocean in addition to that of the sun. The prevailing winds in the British Isles being west-south-westerly, the influence of the ocean on the temperature of the air is much greater in the west than in the east. The mean temperature is everywhere higher on the west than on the east coast. The temperature of the sea on the west coast is about 3° F., or 1·7° C., higher than the temperature of the air of the west coast, and that of the sea on the east coast 1° F., or 0·6° C., only above the mean air-temperature of the east coast. The lowest mean temperature in the British Isles is 31·2° F., or −0·4° C., and is found on the summit of Ben Nevis, and the highest is 52·2° F., or 11·2° C., in the Scilly Isles and in Truro, Cornwall.

The actual mean temperatures of some of the chief towns are as follow :—

London =50·4° F.
Jersey =51·9° F.
Plymouth =51·4° F.
Birmingham =48·8° F.
Liverpool =49·8° F.
Douglas, Isle of Man =48·7° F.
Rothesay =47·0° F.
Glasgow =47·5° F.
Edinburgh =47·1° F.
Aberdeen =46·4° F.
Inverness =46·5° F.
Stornoway =46·2° F.
Belfast =48·5° F.
Dublin =49·5° F.
Cork =49·3° F.
Valentia =51·2° F.

Of great importance is the *Amount of Sunshine.* This is recorded by means of Campbell's or Jordan's apparatus. In the former apparatus a glass sphere focusses the pencil of rays upon a sheet of paper placed at the necessary distance on a convex surface. The amount and intensity of the sun's rays are recorded by the amount and degree of scorching of the paper. In the latter apparatus the recorder is a small, flat, circular box in which is a slit. Within the box is sensitised paper, as used in photography. The sunshine, passing through the slit, records itself upon the paper, which appears on "developing" the paper.

Isohels are lines denoting equal durations or periods of bright sunshine.

The number of hours of bright sunshine increases from the north to the south. In the former it is usually less than one-third of the total possible, and in the latter, usually over one-half, and it may be even as much as two-thirds of the possible total. Sunshine also increases from west to east. In the British Isles there are on the average 1200 hours (27 per cent.) of bright sunshine in the north, and 1600 hours (36 per cent.) in the south. In Central Germany it amounts to 1700 hours (38 per cent.) ; in Austria, 1800 to 2000 hours (40 to 45 per cent.); in Italy, 2000 to 2400 hours (45 to 54 per cent.) ; and in the interior of Spain, 2900 to 3000 hours (66 to 68 per cent.). May is the sunniest month in the north-west, and December is the dullest.

Isonephs are lines denoting equal cloudiness. The mode of estimating cloudiness is by noting the percentage amount of sky, or tenths of sky, covered by cloud, within the area of the observer. Scales of known significance are employed. Generally speaking, there is a tendency at all seasons for clouds to be distributed in bands parallel to the equator. Other things being equal, more clouds are found over oceans than over continents, in elevated regions than in low regions, and where a wind passes from a warmer to a colder region than in the opposite way. Cooling of a wind laden with watery vapour produces condensation of the invisible vapour into visible form. In spring, speaking generally, the sky is clearest, as the pressure maximum is still over the continents, and also because there is relatively little aqueous vapour in the air at the end of winter when the temperature begins to rise. Autumn is the cloudiest season because the cooled air is no longer able to hold so much aqueous vapour as it could in the warmer summer, and, besides, the water of the ocean is still at a high temperature, and evaporation from its surface is still relatively large in amount.

II. *Atmospheric Humidity.*—There is always present in the atmosphere a certain amount of moisture in the form of gas, or aqueous vapour as it is termed, which is obtained by evaporation. Evaporation is diminished or increased by the lowering or raising of the temperature, and is limited by any confinement of the space into which the aqueous vapour is passed. The presence of aqueous vapour over the surface of a vessel of water, for example, hinders evaporation—that is to say, the greater or lesser quantity of aqueous vapour already contained in the atmosphere, the smaller or greater will be the amount of evaporation, and the nearer the point of saturation the atmosphere is the less will be the evaporation. During evaporation of water to the gaseous state heat is being constantly communicated to the vapour passing off ; when this heat is withdrawn from the vapour it condenses back into the condition of water. The chief action of watery vapour in the atmosphere is to modify the action of the sun's heat upon the earth, and also the radiation of heat from the earth. The "*point of saturation*" of air is that point at which the air at any given temperature cannot hold any more aqueous vapour in the gaseous form. As is the temperature of the air at any given time, so is the total possible amount of vapour which it can sustain. Most usually, however, the air only holds some proportion of this total amount. Most comfort is experienced when the atmosphere contains 70 to 80 per cent. of the possible total amount it can hold at that temperature When the temperature of the atmosphere at saturation-point falls, the air ceases to be able to sustain the quantity of vapour it formerly held, and part of it is condensed in the form of water, or dew, hence this point is called the *dew-point*. The temperature of the dew-point will, therefore, vary with the temperature of the atmosphere. The term "*absolute*" *humidity* is intended to express the actual amount of watery vapour which the atmosphere can hold at a given temperature—that is, while in a state of saturation; the term "*relative*" *humidity*, that proportion of the total possible amount of aqueous vapour which the atmosphere at a given temperature actually holds. The latter is usually expressed as a percentage quantity or fraction of saturation. The term "*tension of aqueous vapour*" means the measure of the elastic force exercised by the aqueous vapour in the atmosphere, expressed in terms of an inch of mercury.

Starkey, of McGill University, has drawn attention to the harmful[1] effects of deficiency of the atmospheric humidity in occupied rooms in Canada during the winter months. From examinations of the air of rooms made by him he found that the average relative humidity of rooms with the windows closed was lower than when the windows were opened, and even then much lower than the relative humidity of the open air; for example, in January, the room temperature being 66° F., and the relative humidity of the outside air being 78·1 per cent., the relative humidity of the room with the windows closed was only 41 per cent., and with the windows open 57 per cent. This must be due, doubtless, to the furnace method of heating rooms which obtains in Canada. The effect produced upon the occupants is irritation and congestion of the respiratory mucous membranes, sometimes more marked in frontal sinuses, sometimes in Eustachian tubes, and sometimes in the form of chronic hyperæmia of the nasal mucous membrane or of bronchial mucous membrane.

The same deficient percentage of humidity has been said by one or two observers to exist, especially in the winter months, in the air supplied by the plenum system. It has to be borne in mind that the entering air, at a comparatively low temperature, perhaps, as it passes the washing-screen, holding as it then does a certain relative humidity, is then warmed by being passed over the steam coils to a higher temperature—many degrees, perhaps, above that at entrance; hence the percentage amount of relative humidity which would be comfortable in air at the lower temperature ceases to be so because of the reduction of humidity in the warming process. Further observations are needed, however, to determine how frequently such may happen.

Hygrometry is the mode of determining the amount of aqueous vapour, or moisture, present in the atmosphere, the instruments used being called hygrometers. From the results recorded by these, relative humidity, dew-point, and tension of aqueous vapour are determined. Hygrometers are of two kinds—viz. direct, and indirect. The instruments of Daniell, Reynault, and Dine belong to the former class, while the pyschrometer or wet-and-dry bulb thermometer, and Saussure's or the hair hygrometer belong to the second.

Direct Hygrometers.—In the three first-named instruments the temperature at which dew deposits is brought about by cooling; in Daniell's instrument, by the cooling produced by evaporation of ether from an outside muslin coating which covers the clear bulb;[1] in Regnault's by the passage of a current of air which is aspirated through the ether, and in Dine's by the use of very cold water, or iced water. The points to be noticed are these—viz.

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[1] *Montreal Med. Jour.*, March 1906.

1. The temperature at which dew deposits on the opaque bulb, or glass-plate;
2. The temperature at which it disappears;
3. If the mean of these two observations be taken, that is the "dew-point" temperature;
4. Take the "tension" corresponding to the temperature of dew-point (obtained from a table of tensions), divide it by the tension corresponding to the temperature of the air at the time, and the result will be the hygrometric state of the atmosphere in terms of relative humidity.

The objections to Daniell's instrument are: (*a*) liability to incorrect reading of immersed thermometer; (*b*) compulsory proximity of observer affecting temperature recorded by attached thermometer. Regnault's instrument is very efficient. Dine's is simpler than the other, and is also very efficient.

Indirect Hygrometers.—The wet-and-dry bulb thermometer is the instrument now most commonly used. It consists of two thermometers, the bulb of one of which is coated with muslin to which is attached a small bundle of wick threads, both of which are kept moistened by capillary action, the ends of the threads being caused to dip into a small vessel of water. The principle of the instrument is, that so long as the atmosphere is not saturated evaporation will take place from a damp surface, and the amount of evaporation will be indicated by the lower reading of the wet-bulb instrument. If the air be saturated no evaporation will take place, and accordingly the readings of both instruments will be identical. A sling psychrometer or whirling hygrometer is a variation of the stationary instrument. The two thermometers are fixed on a strip of metal which is so united to a handle that by quickly turning the handle the thermometers are whirled through the air. The bulb of the wet-bulb thermometer is covered by wick, which, before use, is dipped into distilled water at a temperature corresponding to that of the air of the apartment to be tested.

In the absence of a table of tensions of aqueous vapour the tension may be found by Apjohn's formula from the readings of the above instrument.

Let f = tension of vapour at dew-point temperature, which is to be found;
f' = tension of vapour at temp. of evaporation as recorded by wet-bulb instrument;
a = specific heat of air;
c = latent heat of aqueous vapour;
$(t-t')$, or d = difference in temperature-readings between dry- and wet-bulb instruments;
p = pressure indicated by barometer, in inches:

$$\text{Then } f = f' - \frac{48a\,(t-t')}{c} \times \frac{p - f''}{30};$$

or, with the coefficient:

$$f = f' - \cdot 01147\,(t-t') \times \frac{p - f'}{30}.$$

The Greenwich modification of the formula is as follows, where h = height of barometer :—

$$f = f' - \frac{d}{88} \times \frac{h}{30} = \text{for temperatures above } 32^\circ \text{ F.},$$

$$\text{or } f = f' - \frac{d}{96} \times \frac{h}{30} = \text{ ,, \quad ,, \quad below } 32^\circ \text{ F.}$$

Example.—Find the vapour tension where the temp. of the dry bulb is 65° F., that of the wet bulb 61° F., the tension of the air at 65° F. being ·617 inches of mercury, and of the wet bulb at 61° F., ·537 inches.

$$f = f' - \frac{d}{88}$$

$$f = \cdot 537 - \frac{65 - 61}{88};$$

$$f = \cdot 537 - \frac{4}{88}$$

$$f = \cdot 537 - \cdot 0\dot{4}\dot{5}$$

$$f = \cdot 49145 = \text{tension of vapour at dew-point.}$$

Relative humidity

$\cdot 617$ = tension of vapour of air at 65° F.,

$\therefore \quad \cdot 49145 \div \cdot 617 = 79$ per cent.

The dew-point may also be calculated by the aid of Glaisher's tables, thus : From the temp. of the dry-bulb instrument subtract the reading of the wet-bulb ; multiply the difference by the factor corresponding to the dry-bulb temperature, and subtract the product from the dry-bulb temperature ; the result is dew-point.

Example : The dry-bulb temperature = 53° F.,

The wet-bulb ,, = 49° F.,

Then $53–49 \times 2\cdot 00$ (factor corresponding to 53° F.) = 8.

$\therefore$ $53–8 = 45^\circ$ F. = the dew-point temperature.

Saussure's hygrometer is based on the fact that a hair becomes longer or shorter as the air is damp or dry. In this instrument, a human hair, which has never been oiled or handled roughly, is used, One end of the hair is fixed in the instrument, the other being kept stretched by a light weight attached to it, which weight is attached to a connecting cord pressing round the sheaf of a block, to which is fixed an arm or index moving in a graduated arc. As the hair shortens or lengthens, the index moves and records the difference in vapour present in the atmosphere.

III. *The Rainfall.*—The amount of rainfall is of importance in relation to the maintenance of water-supplies. In the term rainfall is included all moisture which falls in particulate drops, either as a liquid or solid, as rain, snow, or hail. The amount is estimated by rain-gauges, of which Howard's, Glaisher's, the Snowdon, and others are the principal. Howard's instrument is the simplest, and consists of (*a*) a funnel ; (*b*) a receiver ; and (*c*) a graduated measuring-glass. Glaisher's differs only in that the receiver is made of copper, and the delivery-tube of the funnel is bent in the form of a curve, in order to prevent evaporation. The Snowdon gauge consists of a funnel with straight stem enclosed in a cylinder—for better snow-collection—having a diameter of eight inches. The position of the gauge is of importance, in order that the true fall be estimated. It must be put at a height—from brim to ground-level—of not less than one foot ; it must be firmly fixed, and its brim perfectly level; evaporation should be prevented so far as possible; and it must be placed in a perfectly open position, so that the rainfall will not be influenced by sheltering objects, as trees, walls, shrubs, etc. The amount of water in the receiver should be measured at the same hour—preferably 9 A.M.—and the result expressed in inches and decimals of an inch. Snow and hail should be melted first before measurement. The factors to be known in the estimation are: (1) the area of receiving-surface of the gauge, which being circular is the square of the diameter + ·7854; and (2) amount of water in the receiver, measured in a graduated glass. The amount of rainfall has a certain close relation to the prevailing winds. In these islands, the greatest rainfall obtains with the westerly and south-westerly winds, which crossing the Atlantic charged with moisture tend to deposit it as rain on the western sea-board. For this reason, highest rainfalls are recorded on the west and south-west, and the lowest on the east coasts. The presence of elevated land affects the incidence of the rainfall. When a current of air charged with moisture comes in contact with mountain or hill tops, condensation occurs, and the rain falls. It is by reason of the more mountainous character of the western sea-board, as one cause, that higher rainfalls prevail there than upon the eastern shores. The average annual rainfall of the western coast of Scotland or Ireland amounts to 60 or 80 inches, while on the eastern it only reaches from 20 to 35 inches. We have computed the total rainfall in the British Islands, with a total acreage of 76,650,219, and an average fall of thirty inches per annum, to amount to 232,000,000,000 tons of water; but a very large proportion of this finds its way back to the sea by the rivers, and to the atmosphere by surface evaporation. Taken as a whole, it is calculated that one-third or one-quarter of the total rainfall flows off the surface upon which it falls, and that the remainder is partly absorbed into the soil, and partly given back to the atmosphere by evaporation.

Isohyets are lines denoting equal rainfall.

Much information has been collected regarding the distribution of the rainfall in the British Isles.[1] In the paper under the former reference a period of twenty-five years' (1866–1890) observations was the basis of the conclusions which were set down in colours on thirteen maps. Twelve of these give the average rainfall in Scotland, each for one month of the year, and the remaining map the average rainfall over the whole year for the period of years covered by the inquiry. In the last-named it is shown that the district of least rainfall per annum is along the southern shores of the Moray Firth, where it is 30 inches or less. This district includes the whole of the county of Nairn and a good part of Elgin county. Glasgow falls within the 30 to 40 inch annual fall. Wigtownshire, including nearly all Dumfriesshire and most of Ayrshire and Renfrewshire, experiences an average annual fall of between 40 and 60 inches. Greenock has an average fall of 64 inches. Western Perthshire, a large part of Inverness-shire, a part of Ross-shire and parts of Skye have between 60 and 80 inches, Fort Augustus, 108 inches, Ardlui, at the head of Loch Lomond, 115 inches, Glencoe, 128 inches, and Ben Nevis, 144 inches per annum. The lowest average rainfall during this period was at Spurnhead in England, with 21·2 inches, Nairn in Scotland being 23·33. The highest average annual rainfall is not experienced in Scotland, but in England. At Styehead, in Cumberland, during that period it was 185 inches. The heaviest rainfall on record during a single day occurred at Seathwaite in Cumberland in 1897, when it amounted to 8·03 inches. The rainfall of London is, on the whole, low. Camberwell and Hampstead show a fall of about 27 inches, Streatham and Wimbledon and Deptford, between 24 and 26 inches; while Westminster, Battersea and Finsbury show the lowest for London. The south-western and north-western counties of England compare with similar counties of Scotland, and Wales generally is on a like scale, although in Carnarvon, Merioneth, and Brecon the fall reaches over 100 inches per annum.

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[1] *Mill. Jour. Scot. Meteorolog. Society, Rainfall of* 1908.

IV. *Atmospheric Pressure.*—Gaseous bodies have certain common properties with liquids. They possess weight, and they transmit pressures equally in every direction. A litre of air at 32° F., at a pressure of one atmosphere weighs 1·293 grammes; water in like conditions weighs 1000 grammes; therefore, 1000 ÷ 1·293 = 773; in other words, air is 773 times lighter than water. The atmosphere is a gaseous mantle which envelops the earth, and has been estimated to attain a height above the earth of from 50 to 212 miles. It exerts, at the same level, pressure equally and in every direction upon every object, animate and inanimate. But on account of the compressibility of gaseous bodies, the lower levels of a high column are denser than the higher; but even in these, the pressure is equal and constant at the same time and at the same level. Whenever inequality of pressure occurs at any two or more adjacent points of the atmosphere movement of air is at once set up. Torricelli's experiment proved this law: that the pressure of the atmosphere at the earth's surface on

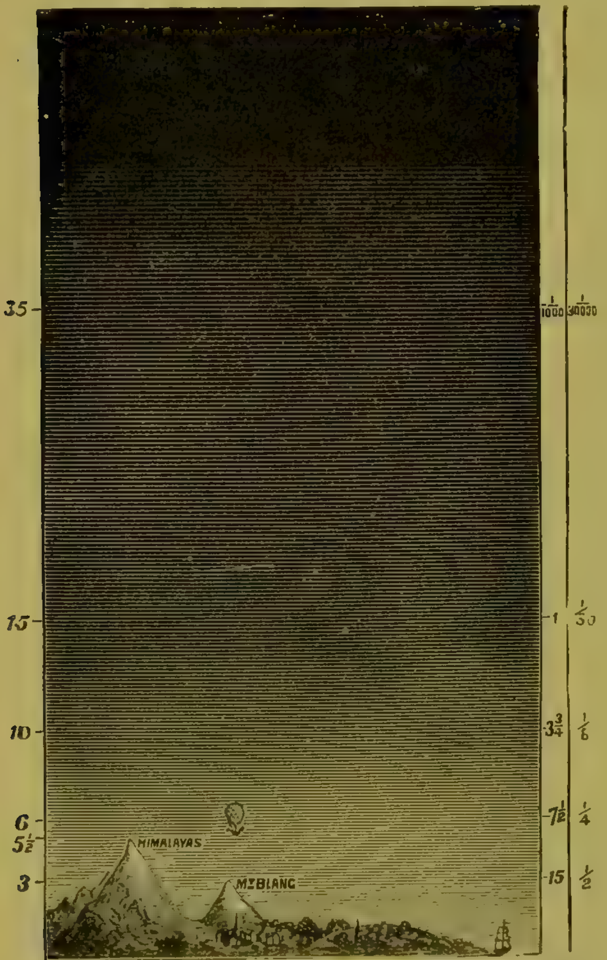

FIG. 3.—The figures on the right of the diagram show the readings of the barometer in inches corresponding to those on the left of height in miles.

the sea-level is equal to the weight of a column of mercury of a height of 30 inches. If the same experiment be performed with water, the column would reach 30 feet in height, since the density of mercury is 13·59 times greater than that of water; and if with glycerine, the column would be 27 feet high, since the density of glycerine is 1·26 times greater than water. Variations of pressure are much more easily read in a glycerine barometer, because of the greater range of the movement of the fluid; for example, the pressure which would raise or depress the mercurial column 1 inch would raise or lower the other 10·7 inches. Such an instrument is in use in *The Times* office, London.

The pressure of the atmosphere in this country is generally calculated as upon a square inch of surface—that is to say, it is the weight of a column of mercury whose base is a square inch and whose height is 30 inches; in other words, the weight of 30 inches of mercury. Accurately weighed, this amounts to 14·73 pounds, usually reckoned as 15 pounds. Owing to the laws of gases, the higher levels of the atmosphere sustain a less pressure than the lower, consequently the column of mercury becomes lower in height as ascent is made into the higher reaches. Hence at an altitude of 12,000 feet above sea-level the pressure is only one-half of that at sea-level. In Great Britain the mercury falls one-tenth of an inch for every ninety feet ascended. From the Torricellian tube was constructed the instrument to which Boyle gave the name of barometer. British barometers are graduated in divisions of $\frac{5}{100}$ths, tenths, half-inch, and one-inch divisions; the last two divisional lines being bolder than the rest.

Reading the Barometer.—For the more accurate observation of the height of the mercury, and since the exact level may be between the hundredths of an inch, most modern instruments have attached to them a graduated sliding arm which is called the "vernier." It is so graduated that twenty-five of its divisions are equal to twenty-four of the main scale, hence each division of it is only $\frac{24}{25}$ of the length of the division of the main scale. The divisions on the barometer being $\frac{1}{20}$ of an inch, the vernier will, therefore, enable a reading to be made of $\frac{1}{25}$ of $\frac{1}{20}$ or $\frac{1}{500}$ of an inch. To use the vernier, its lowest mark is accurately placed on a line level with the top of the mercury. This adjustment may or may not be exactly level with a line on the main scale; if level, the vernier is not needed, as the reading from the main scale will be accurate and sufficient. If not, however, the eye should be run up the line of junction of the vernier and main scales until a point is reached where a line of the vernier is exactly level with a line of the main scale. Suppose, for example, that the mercury stands above 29·65 but below 29·70, and that the point at which the two lines of vernier and main scale correspond is at sixteen divisions of the vernier scale counting from below upwards, then the reading of the instrument will be as follows—viz. $29{\cdot}65 + (16 \times {\cdot}002) = 29{\cdot}682$ inches. If greater accuracy even than this be desired, the cathetometer, which is employed in the highest scientific work, may be used.

The *Cathetometer* is an instrument which consists practically of a telescope set in levelling screws, with an adjoining spirit-level, and has a vertical scale usually divided into half-millimetres. In the telescope part, and in the focus of the eye-piece, are set two very fine lines. By means of adjusting apparatus, the telescope is moved over the scale so that the exact level of the mercury in the barometer, as ascertained by the lines, may be read. Each mercurial barometer has an attached mercurial thermometer, for noting the temperature at the time of the observation.

Mercurial barometers are of different kinds—viz.

1. The Standard, Kew or Fortin's barometer;
2. The Siphon barometer;
3. The Wheel barometer;
4. Adie's barometer.

1. In the Standard or Fortin instrument, the cistern is formed of a tube of boxwood surmounted by a glass tube and closed below by a piece of leather, which can be raised or lowered by a screw. The starting-point of the scale is formed by a pin of ivory which is so adjusted by the screw operating on the leather bottom of the cistern that its point just touches the level of the mercury in the cistern called the *fiducial point.* The only possible errors in this instrument are (*a*) from capillary depression of mercury in the tube, and (*b*) from the temperature or readings of the thermometer. Adie's instrument, known also as the Kew or Marine barometer, is a modification of the foregoing instrument, and like it only requires one reading. The scale is marked on the instrument, but instead of the inches being marked uniformly true, they are shortened from above downwards, in proportion to the relative sizes of diameter of tube and cistern, but the highest point of the scale is correctly marked from a definite point which is marked on the side of the cistern. In the Marine form, the only difference is that the tube is contracted at some part of its length to prevent oscillatory movement due to motion of the ship.

2. The Siphon barometer is of quite different construction. It has no cistern whatever, but a U-shaped tube is substituted in its place. The U consists of a long leg and a short one, the former being closed, the latter open. As the mercury rises in the long limb, it necessarily falls in the short one; as a consequence, a reading must be taken from each side. No capillary correction is required for this instrument, and it is probably the best mercurial instrument for mountain ascents.

3. *The Wheel Barometer.*—This is practically a modification of the siphon instrument, in respect that a float placed in the open short limb rises or falls as does the column of mercury, which float, by means of a string and block, transfers motion to a lever acting like the hand of a clock, and is magnified on a dial, which is prepared from observations. This instrument has also been used to record automatically by suitable mechanical arrangements the rise and fall of the mercury, and is then called a *barograph.*

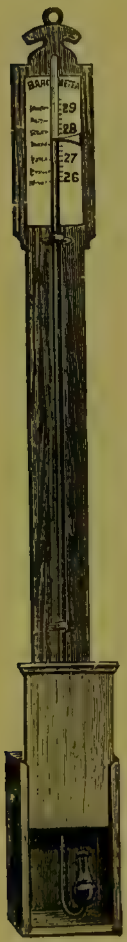

FIG. 4.—Mine Barometer.

In addition to mercurial barometers, there are other instruments for measuring the atmospheric pressure—viz.

(*a*) The Sympiesometer;
(*b*) The Aneroid Barometer.

The *Sympiesometer* (or a measurer of compression), known as Adie's instrument, consists of a glass tube, 18 inches in length and $\frac{3}{4}$ of an inch in diameter, which has a small chamber at the top and an open cistern below. This upper chamber and upper part of the tube contain air, and the remainder of tube and the cistern are filled with glycerine. As the atmospheric pressure increases, the air in the upper part of the instrument is compressed and the glycerine rises; should the pressure on the other hand diminish, the air expands and the glycerine-level falls. It is graduated by comparison with a mercurial barometer, but owing to the respective different densities of mercury and glycerine the intervals corresponding to inches in the one become much greater in the other and are of unequal length, being shorter as the tube is ascended. To the instrument are added a thermometer and a sliding scale which can be adjusted for the temperature found at each observation. It is a very sensitive instrument.

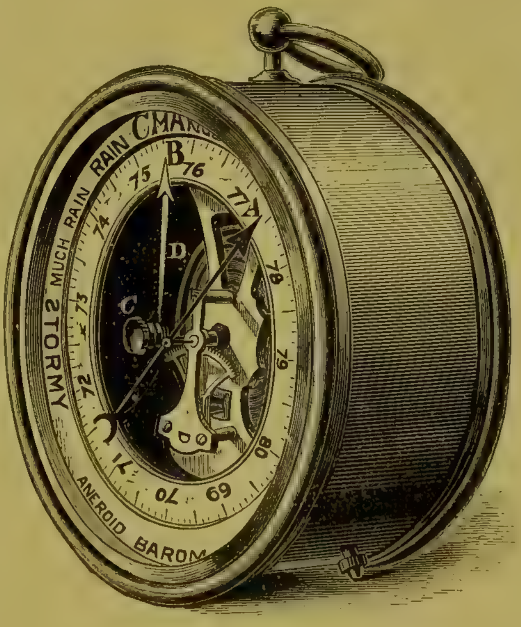

Fig. 5.—Aneroid Barometer.

The *Aneroid* Barometer.—This instrument is extensively used by reason of its compact form and portability, and depends for its action upon the changes in form which a thin metallic box, in a condition of partial vacuum, experiences on differing degrees of pressure. The greater the pressure of the atmosphere the greater the compression of the metallic box; when the pressure becomes less, the box is replaced to its former state by a spring. The instrument essentially consists of (1) a vacuum chamber which is composed of two discs of corrugated German silver formed into a box-shape by soldering; (2) a base-plate. The vacuum chamber is attached to the base-plate by one pin, and to a strong spring by another pin which is borne by the frame of the instrument. The spring acts in opposition to the movement of the walls of the vacuum chamber. Attached to the spring is a lever composed of iron and brass—intended to act as compensation for temperature—which is connected by another bent lever to a chain wound round the *arbour*. The spiral-spring keeps the chain tightly wound round the barrel, and the chain operates on the hand or index which moves over the dial-face, by reason of the rotatory action of the barrel. These instruments are all graduated and compensated for temperature, are good, and are at first sensitive instruments, but they are liable in time to become inaccurate from imperfect workmanship, corrosion, and other causes.

Defects in Mercurial Barometers.—The presence of air or moisture in the Torricellian space renders an instrument useless by reason of inaccuracy, inasmuch as the expansion of contained air, or the elastic force of watery vapour, tends to counterbalance the pressure of the outside atmosphere, and to cause the mercury to act sluggishly. If a barometer tube has been properly filled, by tightly stopping the lower open end with a finger and suddenly depressing the closed end, a sharp, metallic click of the mercury against the glass will be heard. Ingenious arrangements have been made to prevent the access of air or moisture, but in modern instruments these are not commonly found. In order that barometric observations in different places may be comparable, the readings must conform to certain standard conditions, for which the barometer requires corrections. Such barometric corrections must be considered (1) with reference to the individual instrument; (2) with reference to all mercurial instruments. Those necessary for any individual instrument are (*a*) *index error*; (*b*) *capacity*; (*c*) *capillarity.* The index error includes errors of graduation of the scale of the instrument, and the position of the zero of the scale; the latter makes readings of the instrument either too high or too low, the former are often different for different parts of the scale. These are rectified by comparison with a standard instrument at Kew, and the corrections are supplied with the certificate. Correction for capacity is not usually required in the newer instruments. When present, however, its amount depends on the proportion of the sectional area of the tube to that of the cistern. Correction for capillarity is sometimes needed, since a certain amount of capillary action occurs between glass and mercury which tends to depress the mercurial column. This is liable to be greater the smaller the bore of the tube.

The corrections common to all readings of instruments are two in number—viz. (*a*) for temperature, (*b*) for altitude. *For Temperature.*—Mercury expands by heat, consequently a heated column of that metal gives a higher reading. It is therefore necessary to reduce the reading to the temperature of the freezing-point of water, which is commonly called the "reduction to 32° F." The coefficient of expansion of mercury for each degree Centigrade is ·00018018, and for each degree Fahrenheit ·0001001 above freezing-point. *For Altitude.*—Since altitude affects the reading of a barometer by reason of differences of pressure, it is necessary to correct the reading of every barometer to a standard level, which, for Great Britain, is *the mean half-tide level at Liverpool*, and the correction is thus known as the "reduction to sea-level." The altitude of any place of observation above this level may be ascertained from the Ordnance Survey maps. The simplest, and at the same time fairly accurate, rule is to estimate the difference of the readings of the barometer between the points at which the observation is taken and the sea-level in hundredths of an inch, and to multiply by 9; the result gives the difference in altitude in feet. This method is based on Strachan's observations that a height of 90 feet gives a difference in barometric reading of 0·1 of an inch.

The term "*isobar*" means a line of equal barometric pressure, and as the force of the wind depends upon differences of pressure, these differences of pressure between isobars of different pressures are termed *gradients*, which is a term expressive of such different lines or points of pressure over a given distance. The units of pressure and distance in this country are respectively 0·1 inches and fifteen geographical miles, or, in the metric system, one millimetre and one degree or sixty geographical miles. These isobars or lines of equal pressure assume certain typical forms, and determine the force and direction of winds. Of these forms the principal are (*a*) the cyclone, (*b*) anti-cyclone, (*c*) V-shaped depressions and (*d*) straight isobars. The cyclone is characterised by concentric isobars, the lowest pressure being found in the centre, the gradients being steep. The anti-cyclone is also characterised by concentric isobars, less definite, however, and further apart, the highest pressure being in the centre, the gradients being less steep than in the cyclone. In V-shaped depressions or wedges of low pressure, the pressure is highest in the interior, and they are usually found between two adjacent anti-cyclones. There are also wedges of high pressure between two adjacent cyclones. In cyclonic areas of pressure, the wind blows spirally or obliquely into the centre, which is the point of lowest pressure, in the reverse movement of the hands of a clock, whereas in anti-cyclones the wind blows spirally or obliquely from the centre—the point of highest pressure—to the circumference, in the direction of the hands of a clock. From such distributions of pressure weather conditions are forecasted. From the steepness of the gradients—that is, the differences in pressure and distance of the isobars—in a cyclone, strong high winds and stormy wet weather may be predicted, followed by bright sunny weather. In anti-cyclones the weather is good; there is little wind, and the air is bracing. Such, however, are apt to be attended by fogs in towns and cities.

Isobaric maps were not apparently thought to be necessary in the earlier days of meteorology, because it was assumed up till about 1869 that the mean pressure at sea-level was everywhere the same. But Buchan[1] pointed out that on account of pressures at sea-level being unequal and unequally distributed, it was absolutely necessary to take this factor into consideration, especially in the determination of altitudes. The mean annual barometric pressure of the world is found to be distributed in bands of relatively high and low pressure—low round the equator and round 60° N. and S. latitude, and high round the Poles and 30° N. and S. latitude. The pressure is believed to be high round the South Pole, because the winds, generally speaking, blow from southern regions; but there is as yet little actually known of the precise conditions near the S. Pole.

In the northern hemisphere, around 60° N. lat., the continuity of area of low pressure is broken up, due to the relatively larger proportion of land to water, and owing to this fact the air is very dry, and greatly cooled in winter, whereas over the seas in the same latitude the air is relatively very moist and warm. This contrast is, however, less marked in summer. The minimum of mean annual pressure is confined, therefore, to the bodies of water forming the North Atlantic and North Pacific regions. The maximum pressure in sub-tropical regions extends northwards over the continents across the polar area. The highest mean annual pressure is found in an area about the head waters of the Lena and Yenisei rivers in Asia, where it rises above 30·20 inches or 767 mm. The lowest areas are two in number; one extending from Southern Greenland over Iceland and Spitzbergen, the other from the southern part of the Kamschatka peninsula over the Aleutian Islands and the southern part of the Alaska peninsula; in each of these the pressure falls below 29·7 inches or 754 mm.

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[1] *Trans. Roy. Soc. Edin.*, vol. xxv., 1869.

The student who desires to pursue the subject of meteorology in greater detail will find a mine of information in Bartholomew's Physical Atlas, vol. iii., edited by Alexander Buchan, LL.D., F.R.S.

Atmospheric Movements and Winds.—The determining causes of movements of columns of air are chiefly two in number, viz. (*a*) inequalities of temperature between two adjacent columns, and (*b*) inequalities of pressure; to which may be added movement or rotation of the earth. Wind is merely air in sensible motion. Depending upon the steepness or otherwise of the gradients of isobars within a given area over the earth's surface is the degree of movement of the air, or, otherwise put, the velocity of the wind. The direction of the wind is determined by the position and relationship to each other of areas of differing barometric pressure. The velocity and, therefore, the pressure of the wind is measured by anemometers of different kinds or pressure-gauges. Such instruments, however, must as a rule be reckoned to be approximately correct only, because of the difficulty of securing always the most suitable place for their installation. Where a pressure-gauge is used the velocity is obtained by the formula of James, viz. $P = v^2 \times \cdot005$, and conversely where an instrument which measures velocity is used, the pressure is obtained by changing the terms of the formula thus: $v^2 \times \cdot005 = P$. Velocities are interpreted into weather terms by an arbitrary scale.

The prevalent directions of a wind in any limited locality are mainly dependent on proximity to (*a*) the ocean and (*b*) high mountains, and (*c*) other less well determined factors.

TABLE XXV

Showing Monthly Percentages of Directions of the Wind in Glasgow and District
(1) *from* 1868 *to* 1892, *and* (2) *from* 1893 *to* 1903

(*From Meteorological Register of Glasgow Observatory—Professor Becker*)

Period	Direction of Wind	Jan.	Feb.	March	April	May	June	July	August	Sept.	October	Nov.	Dec.	Whole year
1868–1892	N.	2·9	3·8	6·6	4·4	4·6	2·5	3·0	3·5	3·1	6·0	5·6	5·5	4·3
1893–1903		5·3	6·3	6·4	3·9	5·5	2·4	2·0	2·2	2·6	4·7	4·7	2·4	4·0
1868–1892	N.E.	12·4	16·0	15·6	23·2	17·9	13·6	11·7	13·0	15·0	17·6	18·1	13·9	15·6
1893–1903		9·6	10·6	9·6	11·6	15·5	16·3	9·3	8·3	7·3	10·4	10·5	8·2	10·6
1868–1892	E.	12·2	14·4	15·1	20·8	17·9	17·3	13·2	12·4	12·5	9·8	12·4	12·7	14·2
1893–1903		11·4	12·3	9·2	17·0	21·6	19·4	12·4	11·0	12·3	12·3	15·1	13·8	14·0
1868–1892	S.E.	7·2	5·6	3·9	5·0	4·7	2·8	3·4	3·7	4·0	5·7	5·8	5·2	4·7
1893–1903		4·1	4·4	3·5	5·1	2·1	1·9	1·8	3·6	3·6	3·0	4·3	7·2	3·7
1868–1892	S.	12·6	11·4	6·9	7·1	7·6	6·1	7·5	6·6	7·4	8·1	8·2	9·9	8·3
1893–1903		7·2	9·8	8·2	7·5	4·7	5·1	3·3	6·6	6·4	6·9	8·2	8·1	6·8
1868–1892	S.W.	31·3	24·1	21·9	16·4	20·3	21·1	24·8	26·0	26·0	25·3	24·2	27·6	24·1
1893–1903		24·4	22·6	24·8	15·2	10·9	13·7	20·5	20·2	19·9	22·5	21·6	25·0	20·1
1868–1892	W.	16·8	18·7	21·7	15·9	19·4	28·0	28·3	27·3	23·7	18·7	18·1	17·0	21·2
1893–1903		18·5	15·2	19·6	21·8	19·8	23·3	29·3	27·1	24·0	16·9	17·5	18·0	20·9
1868–1892	N.W.	4·6	6·0	8·3	7·2	7·6	8·6	8·1	7·5	8·3	8·8	7·6	8·2	7·6
1893–1903		4·9	4·1	6·5	6·0	6·7	4·6	7·2	5·2	4·9	5·1	3·2	5·0	5·3
1893–1903	Calm	14·6	14·7	12·2	12·0	13·2	13·3	14·2	15·7	19·0	18·2	14·9	12·3	14·5

If the foregoing observations be worked out as numbers of days per annum in each of these periods, 1868–1892 and 1893–1903, during which the wind blew from the directions noted, the results might be tabulated as follows :—

TABLE XXVI

Direction of Wind	Average Number of Days per Annum during 1868–1892	Average Number of Days per Annum during 1893–1903
N.	15·7	14·6
N.E.	56·9	38·7
E.	52·8	51·1
S.E.	17·0	13·5
S.	30·3	24·8
S.W.	88·0	73·37
W.	77·3	76·29
N.W.	27·7	19·35
		Calm = 53·00
Totals	365·7	364·71

It will thus be seen the west-south-westerly winds are the most prevalent, and the east-north-easterly the next, in Glasgow and the West of Scotland.

Since weather conditions, such as dull, foggy, and wet days, and lowered temperatures, provoke disease, these meteorological facts are not without interest to the medical officer of health.

PHYSIOLOGICAL EFFECTS OF ABNORMAL ATMOSPHERIC PRESSURES

Man has so long been accustomed to live within limited distances at or above the sea-level that it is difficult to acclimatise him, without risk to health or even life, to pressures which are either markedly greater or less than normal. Hence it is that by the utilisation of compressed air at pressures greater than normal, by which so many important engineering schemes have been carried to a successful issue, and without which none could have been attempted, men have to be subjected at some risk to life and health to increased atmospheric pressure during their hours of labour. The main physiological effects perceptible to one in an atmospheric pressure of about 24–27 lbs. per square inch are mainly as follow :—first, a sense of fulness in the head in the neighbourhood of the internal ear accompanied by deafness. This is due to the unusual pressure exercised upon the tympanum from without, and the want of equilibrium of air-pressure in Eustachian tube and outer ear on that structure. The foregoing sensation may, therefore, be largely, if not entirely, removed by Valsalva's method of inflating the Eustachian tube, or by performing frequently the act of swallowing. Should this manœuvre not be adopted, rupture of the tympanum may ensue. Second, pains in the forehead over the frontal sinuses, with or without accompanying epistaxis. Third, owing to the rise of blood-pressure and increased action of heart, hæmoptysis may occur. Fourth, there is some degree of arterialisation of the blood of the superficial veins of the body. Some of these effects we have personally experienced during visits to underground works in which the pressure was as named above. In workmen who are, however, exposed to such pressures for hours on end, more serious results may ensue, as for example faintings, pains in limbs and joints, with tenderness on pressure over the seat of the pains, epigastric pains, with or without nausea and vomiting, and paresis or even motor and sensory paralysis of limbs. A pale, earthy or leaden appearance of countenance has also been observed in workers in compressed air. Snell[1] attributes this last condition to the effects of imperfect ventilation. This author goes so far indeed as to affirm that the amount of illness found in such workers is largely attributable to the want of ventilation in the working-place. There is no doubt that the percentage quantities of CO_2 found in the working-place is often very high.

The history of compressed-air illness began with the introduction of the diving-bell, the invention of Sturmius in the early part of the sixteenth century, although it was not then, perhaps, known. Brizé-Fradin[2] was probably the first to give an account of the physiological effects produced in this way. The caisson or caissoon, which is now the mechanism adopted in engineering projects in which compressed air must be employed, was first used by M. Triger in 1839, at Chalonnes, while digging through a layer of quicksand to get down to the coal strata. A modern caisson consists of a steel cylinder sunk or driven vertically or horizontally into water or water-containing soil, the object of its use being to form a shaft or working-space which shall be kept free of water. The possible inrush of water is prevented by the force or pressure of the compressed air which is injected into it from an air-compressing apparatus. The degree of pressure varies on account of the needs of the work to be accomplished. To allow of the entrance and exit of workmen and materials to the working-face, air-locks or air-chambers are provided. For workmen the air-lock is usually double, having an inner and outer airtight door, both of which open toward the compressed-air space. Into the chambers between the doorways, by means of air-cocks connected with the air-compressing machinery, the pressure in the air-chamber, in the case of ingoing workmen or material, is gradually raised to that of the working-face, and in the outgoing chamber the pressure is gradually reduced to the normal pressure of the atmosphere. The pressure at the working-face over that of the normal atmosphere may vary from a few pounds up to forty or more pounds per square inch.

Much attention has been paid of late years to the conditions of work under compressed air, to the workmen employed thereunder, and to the illnesses and fatal results which have resulted therefrom. These questions have also been subjected to experimental investigation both on man and on the lower animals. Greenwood carried out a valuable investigation in his own person in 1905,[3] and has recorded his observations and personal experiences. He permitted himself to be compressed to + 92 lbs.—that is, a total pressure of seven atmospheres—in fifty-four minutes, and subsequently to be decompressed in two hours seventeen minutes, without experiencing any inconvenience beyond a little neuralgic pain in the arms, which, however, disappeared in one and a half hours afterwards. This pressure corresponds to a water depth of about 210 feet.

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[1] "Compressed-Air Illness," 1896.

[2] *La chimie pneumatique appliquée aux travaux sous l'eau*. Paris, 1808.

[3] *B.M.J.*, vol. i., 1906, p. 912; *ibid.*, p. 983.

It is important that men who are to work under compressed-air conditions, and especially at the higher pressures, should be sound and healthy men, and it is absolutely essential to safety as regards life and illness that the time occupied in the decompressing process on coming from the working-face should be ample. It is probably true to say that mischief almost solely arises from deficient time of decompression. Greenwood sets down as the essentials of safe working the following guiding rules, viz. (1) that twenty minutes for each atmosphere of pressure above the normal should be the time allowed for decompression, and that the decompressing process should be gradual and continuous throughout the time, and (2) that during the period of decompression all parts of the body should be quietly exercised, the joints flexed and extended, and the muscles contracted, so as to maintain the capillary circulation in every part.

The same essential conditions as to exposure to compression obtain in deep-sea diving, a report by the Admiralty on the subject having been published giving the results of the investigations of a committee.[1] It is obvious, however, that in diving other means of decompression than in the air-lock had to be devised, hence the plan of discontinuous or staged decompression has been instituted. Rules to be observed in carrying out the system have been instituted. The following quotation from the Addenda to the Diving Manual will illustrate the practice recommended :—" If a diver has been working at a depth of 144 feet for between 45 minutes and 1½ hours, he is directed to ascend rapidly to 50 feet, and then to pause for 10 minutes ; he next comes to 40 feet and again waits 10 minutes ; at 30 feet he stops 20 minutes ; at 20 feet, 30 minutes ; at 10 feet, 35 minutes ; and then leaves the water ; the whole ascent occupying 108 minutes. By the method of uniform decompression the ascent would have been performed in about 126 minutes. Had the exposure been longer—over 1½ hours—the same plan would have been followed, but the total time allotted greater, viz. 178 minutes."

It has been pointed out that the rate at which different animals and parts of animals take up gas when exposed to air under compression " is proportional to the volume of the blood relative to that of the tissues and the rate of circulation. Thus the blood itself comes into gaseous equilibrium with the alveolar air practically instantaneously, and the kidney becomes saturated in a few minutes ; on the other hand, there is abundant evidence that some parts of the body in man do not reach saturation for at least four or five hours. In the same way, when, after exposure to compressed air, the pressure is suddenly released, the excess gas which has been taken up will escape from different tissues at rates which will depend upon the activity of the circulation in the various tissues."[1] It might be expected, therefore, to find, as they are found, air-bubbles in the tissues distributed in accordance with that view. But they are found abundantly in bodily fluids, and still more abundantly and more frequently in blood than in any other fluid of the bodies of animals where decompression is rapid. They are found most commonly and abundantly in fatty tissues compared with any other solid tissue of the body, and in the solid matter of the spinal cord. In experiments made on goats, sudden decompression was found to be most lethal, as the following table shows :—

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[1] Admiralty Committee on Deep-Water Diving, 1907.

TABLE XXVII

Goat	Pressure	Exposure	Decompression	Time of Death
1	72 lbs.	4 hours	40 seconds	20 minutes
2	75 „	2 „	45 „	17 „
3	51 „	3 „	2 minutes	24 „
4	51 „	3 „	4 „	27 „
5	45–46 „	2 „	7 „	190 „
6	25 „	2 „	28 seconds	Died at once

The presence of air-bubbles—some think nitrogen-bubbles—in the blood gives a clue to the likely cause of rapid death following insufficient decompression, viz. air-embolism; and their presence in the solid matter of the spinal cord, to the cause of the paralysis, especially paraplegia, which is not an uncommon sequent to exposure to compressed air. It is also by no means unlikely that it is the presence of these bubbles in the synovial fluid of the joints which gives rise to the joint-pains or "bends" in less serious cases of illness. These surmises are so far corroborated by the experience that the most effective form of treatment of men who suffer in any of these ways after exposure to compressed air is to place them in a hospital air-compression chamber, and gradually raise the pressure. Pains in the joints and in the limbs quickly then disappear, and improvement, if not, indeed, cure, of paraplegic symptoms not infrequently follows.[2]

Mountaineers and balloonists on the other hand suffer from the effects of abnormally low pressures and from the deficiency per cent. of oxygen which such low atmospheric pressure indicates. *Mal de montagne* is a well-recognised affection, the chief symptoms of which are severe headache, great ennui and inability for exertion, and panting for breath. According to Hepburn,[3] true mountain-sickness only supervenes at altitudes at and above 16,500 feet. The conditions of the mountaineer are, however, somewhat different from those of the aeronaut; those of the former are most largely due to diminution of oxygen per unit volume of air, whereas those of the latter are mainly attributable to reduction in pressure, as well as to diminution of oxygen.

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[1] Boycott and Damant, *Jour. of Path.*, vol. xii., 1908.

[2] Further references: Haldane and Lorrain Smith, *Jour. Phys.*, vol. xxv., p. 331; Hill, *Lancet*, 1st July 1905; Hill, *Roy. Instit. Great Britain*, 25th May 1906; Hill and Macleod, *Journ. Hygiene*, vol. iii., p. 403; Macmorran, *B.M.J.*, vol. i., 1902, p. 1018.

[3] *St Barth. Hosp. Reports*, 1895.

The effects of variations of barometric pressure within the limits of natural conditions upon the health of man and upon disease are not yet well, certainly not fully, understood. Some are more readily than others affected by discomfort on ascension to the higher altitudes, some only to the extent of increased rapidity of breathing and of cardiac action, and others to graver symptoms denominated under the term "*mal de montagne.*" Sphygmographic tracings not infrequently show a lower arterial tension at an altitude of 3000 feet than at half that height, although not always. Organic heart-disease is said to be more prevalent among persons living at high altitudes than near the sea-level, these being attributed to the strain on the circulatory and respiratory symptoms when climbing at work in the rarefied air ; but there are not, as yet, sufficient data to establish this point. With respect to the blood of persons and animals living in the higher altitudes, it seems to us to be established that it is richer in corpuscular elements than at lower altitudes. This has been shown by many observers, whatever is the true reason. Dyspepsia has many times been observed to follow residence at high altitudes, and in many cases to persist during the whole period of residence there, but is cured by removal to a lower altitude. Mental inactivity, and, sometimes also, nervous symptoms have been exhibited.

Few observations have been published respecting the influence of variations of barometric pressures near the sea-level on ordinary diseases. Whitelaw[1] has drawn attention to the occurrence of hæmorrhages from the body concomitant with a high barometer ; but the data as yet published cannot be said to prove the association as cause and effect, although *a priori* it seems a feasible hypothesis.

Disastrous explosions, accompanied in some instances with great loss of life, occur in coal-pits at times of high pressure, this having been so frequently observed that "colliery warnings" are issued when the barometer is high.

CLIMATE

Climate may be said to be the resultant of the combined influences of temperature, atmospheric humidity, rainfall, barometric pressure, sunshine, exposure, wind, altitude, proximity to or distance from warm ocean-currents, altitude, and geographical position relative to the equator, on the life of animals and man. Many different classifications of climate have been made, the *fundamentum divisionis* depending upon the object in view. The meteorologist, for example, has divided them into *insular* or *moderate* and *continental* or *excessive*, the main differentiating feature being the moderate range of annual temperature in the one and the extreme range in the other : the isothermal lines being less varied in curvature in the former than in the latter, owing to the different specific heat of land and water. Other classifications have been founded on the relations to the equator, and others again to altitude. But other classifications have been proposed based on their relation to the comfort and health of man; thus:

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[1] *B.M.J.*, vol. i., 1896, p. 1317.

1. Very cold
    - Dry
    - Moist
2. Very hot
    - Dry
    - Moist
3. Sea climates
    - Ocean
    - Island
    - Seashore
4. Inland Climates
    - Valley
    - Plain
    - Mountain

Such a classification is unscientific because there is no definite basis of division.

Lesieur[1] divides climates as follows:—I. *Temperate Climates*: Between the isothermal lines + 15° C., and + 5° C., the influence of the Gulf Stream affecting the boundaries of the latter isotherm; II. *Warm Climates*: Between the isotherms + 25° C., and + 15° C.; III. *Torrid* or *Tropical Climates*: Between the equator + 28° C. and the isothermal line + 25° C.; *Cold Climates*: Between the isothermal lines + 5° C. and − 5° C.; and *Polar Climates*: Between the lines − 5° C. and − 15° C. Such a classification as this, however, is based on lines of equal temperature in relation to place, but takes no regard to time, in which respect it fails as a complete classification.

Huggard[2] has offered a most reasonable classification from the point of view of climate as a remedial measure in disease. His basis of division is the demand made by the climate for the production of body heat or tissue change; and he advances the general proposition that "other things being equal, that climate is most tonic which demands the greatest amount of tissue change that a given organism can permanently yield." He places at the top of his list, therefore, those climates which make the least demand for heat-production by the organism, and at the bottom those which make the largest demand, on the ground that temperature is the only meteorological factor which retains its place as a prominent element of classification for all climates, its influence on the human body for heat requirements being only modified by the mean relative humidity of the air and the presence or absence of winds. Accordingly, he thus divides climates into the following five groups—viz. I. Those where the heat or tissue-change demand is excessively small; II. Those where that is small; III. Those where it is medium; IV. Those where it is large; and V. Those where it is excessive. Grouped relatively to temperature, they are as follow:—I. *Hot Climates*: Having a temperature of over 71·6° F.; II. *Warm Climates*: Having a temperature ranging from 60·8° F. to 71·6° F.; III. *Temperate Climates*: A range from 48·2° F. to 60·8° F.; IV. *Cool Climates*: A range from 33·8° F. to 48·2° F.; V. *Cold Climates*: Having a temperature under 33·8° F. Each of these groups, except the last, is divided into two sub-groups by the mean relative atmospheric humidity, the one sub-group being called *dry*, and the other *not dry*, or *humid climate*. Thus in Group I., the temperature being as stated, a dry climate is one which has a humidity under 60 per cent. and a humid climate one where the humidity is over that percentage; in Group II., under or over 66 per cent.; in Group III., under or over 75 per cent.; and in Group IV., under or over 70 per cent. Group V. has no sub-groups, as its mean relative humidity is 80 per cent. or over.

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[1] *Traité d'Hygiène*, fas. i., Paris, 1906.

[2] *Handbook of Climatic Treatment*, London, 1906.

Cairo affords an example of diversified climate at different seasons of the year. It has a hot dry climate from May till August, a moist climate from September till October, a dry warm climate in March and November, and a dry temperate climate in December, January and February. The Riviera generally from November till April has a dry, temperate climate, although in December and January, Cannes, Nice and San Remo are cool rather than temperate. In South Africa the climate of Cape Town may be classified as temperate from May till October, and as warm from November till March, whereas in the higher lands, further from the sea, the temperate climate begins a month earlier and ceases one month earlier, while the warm climate begins one month sooner and lasts for the same period as at the lower altitudes.

It ought to be pointed out that, with the exception of a few isolated places on the earth's surface, climate is not a fixed quantity, but is subject to fluctuations and variations, because it has relation to time as well as to place. It is in the main true that colonisation is affected by climate, and that nations differ in their capability to colonise regions differing much in climatic conditions from those in which they have been reared. But colonisation depends upon conditions other than adaptability to climatic conditions, hence it is difficult to apportion with close approximation to the truth the grounds for this colonising capacity.

CHAPTER IV

AIR AND VENTILATION

Air—*Composition.*—The purity of the air or atmosphere only becomes an urgent question when Man congregates in large numbers within a small area, and lives within spaces bounded by walls; for under these conditions only is air likely to become so impure as to affect prejudicially the health of those so situated.

Pure air per 1000 volumes has the following constitution:—

Average Composition of Pure Air per 1000 *Volumes*

Nitrogen (including *argon, helium, neon, krypton* and *zenon*)	= 779·0600
Oxygen	= 206·5940
Watery Vapour (as a gas)	= 14·0000
Carbonic Acid, or Carbon Dioxide	= 0·3360
Ammonia	= 0·0080
Ozone	= 0·0015
Nitric Acid	= 0·0005
Total	=1000·0000

If we leave out of count watery vapour, which is variable in amount, then in 1000 volumes the composition may be said to be as follows:—

	By Volume
Oxygen	= 209·6
Nitrogen	= 790·0
CO_2	= ·4
	1000·

For many years the principal gas in the air, apart from oxygen, has been reckoned as nitrogen, but the recent investigations of Lord Rayleigh and Professor Ramsay, and others, have demonstrated the presence in small quantities of the gases which we have included above in nitrogen. They have proved that 100 vols. of pure air contain 0·937 volume of these combined gases, of which argon is the principal component, being, in that quantity, about 400 times greater in amount than the other four put together. Moreover, the physical triumph of the liquefaction of air has made such researches as the chemical composition of air more fertile in results. In addition, however, to these discoveries, Armand Gautier has demonstrated that pure air contains small but appreciable quantities of free hydrogen and of marsh-gas (CH_4). In the air of Paris, as a type of impure air for example, while the presence of free hydrogen was detected upon isolated occasions, the CH_4 amounted to ·226 vols. per 1000 of air. In the air of forests, where it might be expected that marsh gas would be more plentiful by reason of the decomposition of vegetable substances, that gas only amounted to half that quantity—viz. ·113 vols. per 1000; while at a height of 9000 feet in the Pyrenees, amid snow, his experiments demonstrated a still further diminution of CH_4 to ·0219 vols. per 1000, whereas the amount of free hydrogen had increased to ·17 vols. per 1000 volumes of air. While, therefore, the principal constituents of the atmosphere may be reckoned to consist of Nitrogen, Oxygen, Carbonic Acid, Ozone and watery vapour, it does not appear as if its complete chemical constitution was quite so simple as has hitherto been believed.

Oxygen, which so far as human life is concerned may be reckoned as its most important constituent, amounts in the purest air to 20·96 per cent.; but this amount may be appreciably lessened under different circumstances. In breathing, for example, where the oxygen taken into the lungs replaces the carbonic acid gas of the blood, the composition of the expired air differs enormously from that of inspiration. In 1000 vols. of the former, oxygen=169·2, nitrogen, etc.,=790·4, and carbonic acid=40·4 volumes. The other factors which reduce the amount of oxygen are combustion, fermentation and putrefactive processes, manufacturing and trade operations, organic matter in suspension in the air, and others; while those that are restorative of oxygen are mainly the action of vegetable life in splitting up CO_2 in the presence of sunlight into carbon and oxygen, by which the carbon is fixed by the plant and oxygen is liberated, the physical influences of currents of air, and the rainfall. It has been clearly demonstrated that the amount of oxygen in the atmosphere of populous places for the above reasons undergoes a sensible diminution. Angus Smith showed that during frost and fog in the air of Manchester it fell to 20·910 per cent.

Experiments have demonstrated that it is possible for a man to breathe, for a very limited time only without insensibility supervening, an atmosphere which contains only 16 per cent. of oxygen and 4 per cent. of carbonic acid. But remarkable cases occasionally are found. During the construction of a railway bridge over the river Forth near Alloa, in 1882, one man lost his life and the lives of two others were endangered under the following circumstances. The piers of the bridge consisted of hollow iron cylinders. These consisted of segments each about 6 feet in height, which were placed above one another till they reached a total length of 60 feet before the pier was finished. At the junction of each two segments, a space was left all round which had to be filled by a workman from the inside of the pier with a rusting composition which was made up of iron turnings, sulphur, and the addition sometimes of ammonium chloride. One warm, still day in summer, a workman employed in filling up this space with this composition was observed to appear as if overpowered in some inexplicable way. A companion went down to his rescue in a bucket suspended by a rope, placed the man into the bucket, and he was hauled up and revived shortly after. His rescuer, however, in turn became similarly overpowered, and fell into a pool of water at the bottom of the cylinder, in which he was drowned. One of the contractors, after tying a rope round himself, was lowered to the rescue, was likewise overpowered, but was speedily hauled up, and quickly recovered. It was evident that the cause of the mischief was some lethal gas, but what was its precise constitution was not known. The late Dr Wallace, then analyst to the city of Glasgow, came to the conclusion that the cause might be related in some way to the rusting composition used. Having obtained some of the material for experimental purposes, he quickly discovered that when the substances composing it were mixed in a limited quantity of air, the oxygen became so rapidly absorbed that after ten minutes' action the air would not support the combustion of a candle, and that at the end of two hours the amount of oxygen absorbed amounted to 16 parts per 100 volumes of air. Exposure for a still longer period indicated a loss of 20½ parts of oxygen per 100 volumes of air, or nearly the whole amount of oxygen present. Another noteworthy phenomenon observed during the oxidation of the iron of the composition was the considerable rise of temperature of the air, which in one of the experiments reached 156° F. It thus became evident that the cause of the attacks was the limited supply of oxygen due to the oxidation of the iron of the rusting composition, and to the want of circulation of air in the confined space.[1]

Accidents have also happened in caissons from sulphuretted hydrogen gas. A fatal occurrence, due to this cause, took place at Hebburn-on-Tyne in July 1902, and a second in the same place in August of that year, four men in all losing their lives.[2]

Nitrogen serves the useful purpose of diluting the oxygen in the air for the needs of men, animals, and plants, and moreover is an important factor in plant nutrition, since not only are portions of it converted during thunderstorms into nitric acid which is washed into the soil for plant use, but plants, like those of the leguminous order, through the agency of bacteria contained in nodules on their roots, are able to fix the free nitrogen of the air. For the above reason, infinitesimal proportions of nitric acid are sometimes found in the air.

Ozone, which is an allotropic form of oxygen with the chemical formula of O_3, is only found in the air of mountainous regions and of the sea and sea-board especially after thunderstorms, and even then in but small proportions. Because of its property of being rapidly and readily oxidised by organic matter in the air, it is not found in the atmospheres of large populous places.

Carbonic acid may be deemed a normal constituent of air up to a certain point, because of the oxidation of carbon which takes place in nature, but beyond a certain proportion it must be reckoned as an impurity. Existing in the purest air from ·0336 to ·04 per cent., it may be found in the air of populous places in winter to the extent of ·0539 per cent., and in the atmosphere of inhabited, ill-ventilated dwellings, even of 1 per cent. and upwards. In the Cotton Cloth Factories (Amendment) Act, 1887, it is enacted that the air of such factories must not contain more than 0·9 CO_2 per 1000 vols. of air.

In a report to the Home Office in 1902 on the Ventilation of Factories by Haldane and Osborne, it was recommended that the air of factories at the breathing-level should not be allowed to exceed 12 parts of carbon dioxide per 10,000 parts of air during daylight or where electric light was used, or 20 parts after dark where gas or oil was used for lighting.

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[1] *Proc. Phil. Soc. Glasg.*, vol. xiv., p. 1.

[2] *B. M. J.*, vol. ii., 1902, p. 819.

Watery vapour is a variable constituent in air, its amount fluctuating considerably, depending mostly upon temperature. The average amount is about 1·4 per cent. In cotton cloth factories, two sets of standard wet-and-dry bulb thermometers must be kept, and daily readings taken between 10–11 A.M., and 3–4 P.M., of which a record must be made.

The Home Secretary appointed in 1909 a Departmental Committee on Humidity and Ventilation in Cotton-Weaving Sheds, and asked the committee to report on the following matters, viz. "At what degrees of heat and humidity combined definite bodily discomfort arises, under the conditions of the work carried on by the operatives, and what, if any, danger to health is involved by continuous work at those degrees."

Ammonia is always found in impure air, but only in infinitesimal proportions, the average amount not being more than one part per million.

Characteristics of Impure Air.—The air of a populous place differs in its composition from that of the open country or the sea in respect that it contains many impurities, and of different kinds. These may be divided into two main classes, viz. (1) *Particulate,* (2) *Gaseous.* The causes which determine the presence of both are the artificial conditions contingent upon the congregation of Man and animals in a limited area. The former impurities consist of (*a*) unconsumed particles of coal-débris, in the form of soot-particles; (*b*) débris from the bodies of men and animals, from street traffic, and from industrial operations, of organic and inorganic composition; (*c*) spores of plants, pollen, bits of decaying vegetation, fibres of different stuffs; and (*d*) micro-organisms. The particulate bodies are the main causes of fog, since round them are formed halos of condensed watery vapour. The colour and density of fogs are determined by the amount of smut-particles present. It is for this reason that in populous places fogs assume a brown colour and dense character, whereas in the country they are light in colour and have the appearance of mist. Aitken has devised an ingenious apparatus by which the number of particles present in a unit quantity of air may be computed. He has demonstrated that the number of particles per cubic inch of air ranges in number from about 2000 in the air of the open country, to three millions and upwards in populous places. Such particulate bodies, when inspired, generate pulmonary affections because of their irritant character, an action which is seen in more marked degree in persons engaged in certain occupations in which particulate matter of varying kinds is thrown into the atmospheric environment of the workers, and the intensity of which depends largely upon the character of the particulate matter, being more severe where it is of a gritty, angular character than when composed of a soft, fluffy composition. Perhaps of greater importance, however, is the presence of micro-organisms. That their number is greatest in populous centres is demonstrated, as might be expected, by the fact that on mountain-tops, and far out at sea, their number is reduced to a minimum; indeed, from the experimental researches of Miguel, Fischer and others, it has been shown that in high altitudes the average number is reduced to *one organism per cubic metre of air*, and far out at sea, to the vanishing-point. Even in the air of a populous place, however, Frankland, Carnelly, and others have shown (1) that the number of micro-organisms per unit quantity of air is greatest where persons most do congregate in confined spaces, as in halls, schools, churches and like large buildings; (2) that from the effect of gravity the number is greatest on the ground-level, and diminishes by altitude; (3) that after rain or fog the numbers diminish, due to the rain washing the organisms on to the streets, or into the soil. Hence in populous places air-borne infection is more prevalent than in the open country.

Of the gaseous impurities, the chief are (1) carbonic acid and carbon monoxide from the lungs of men and animals, as a product of combustion of coal, of trade processes, and of coal-gas in the air of houses; (2) sulphur gases, as sulphurous acid, sulphuric anhydride, sulphuretted hydrogen; (3) ammonia, as such and in combination with sulphuric acid and sulphuretted hydrogen; (4) other gases from chemical works, etc. The Alkali Acts enact that not more than one-fifth of a grain of HCl and four grains of SO_3 per cubic foot should escape from the works into the air.

Examination of Air for Particulate Bodies.—I. This may be carried out roughly by placing microscope glass slips, moistened with glycerine over one square inch of surface, in different situations and with different time-exposures, in the place to be examined; and thereafter, by examining the slides microscopically with high and low powers of microscope.

II. *By Pouchet's Aeroscope.*—This instrument consists of a funnel-shaped tube drawn out to a point which closely impinges upon a slip of glass moistened with glycerine. These are enclosed in an airtight chamber, which is connected with an aspirator. As the water of the aspirator runs out slowly, air passes into the apparatus, and any particles which it contains are arrested by the glycerine. The glass slip is then taken out and examined by the microscope. Since any definite quantity of air may be aspirated, the number of particles in a given quantity of air may be estimated. For the estimation of the number of micro-organisms in air, probably the best apparatus is that of Hesse, or some modification of it. It consists of a hollow glass cylinder, one end of which is covered by a double indiarubber cap, the other end being connected with an aspirator of known capacity. The cylinder is first of all carefully sterilised, thereafter it is coated with sterilised nutrient gelatine, and the whole is then sterilised for three successive days to ensure the absence of any contained organisms. The cylinder is then mounted on a tripod stand, and is ready for use. The outside rubber cap being removed, a small puncture is made in the inner rubber cap, the aspirator is started in action, and air is thus slowly drawn through the cylinder, the micro-organisms being deposited on the gelatine coating. At the end of the experiment, the quantity of air which has been passed having been noted, the cylinder and contents are incubated, and the number of colonies which grow can then be counted with relation to the quantity of air aspirated. Instead of using a coated cylinder, however, Frankland and others prefer to use a tube which contains sterilised sugar as a packing or filter for the arrest of the organisms, which at the end of the experiment can be melted in sterilised water in sterilised flasks, and after incubation the number of organisms may be counted.

Another method is to expose for different short periods of time the sterilised contents of Petri capsules, the square area of which in inches or millimetres is known, in the atmosphere the microbic contents of which it is desired to examine.

The methods of estimating the impure gases in air will be considered when the subject of ventilation is considered.

Space in Reference to Air-Supply.—The kinds of space of importance with relation to air-supply are superficial space and cubic space, and the one not less than the other. The former is sometimes called floorage. In dealing with the dimensions of any confined space bounded by walls and roof when considering adequacy of ventilation, regard must be paid to both dimensions. Cubic space alone is not enough, since it may be made up in various ways in a confined space. For example, a room might be constructed to contain 10,000 cubic feet of air by very different dimensions—viz.

	Length		Breadth or Width		Height	Cubic Feet
(*a*) . .	50	×	20	×	10	=10,000
(*b*) . .	25	×	40	×	10	
(*c*) . .	20	×	25	×	20	
(*d*) . .	16	×	25	×	25	

But when these proportions are examined with reference to habitability it will be apparent that they are by no means equally suitable. A room, for example, which was only 20 feet long would be ridiculous if 25 feet in height, and, much more so, if of a like height and only 16 feet in length. If, for a moment, we suppose that such a room was to be occupied as a schoolroom under the requirements of the Education Act of 1870, which demands for each child a floor-space of 8 square feet, and a cubic space of 80 feet, then 10,000 ÷ 80 will give the number of scholars for the cubic space as 125. Under the spacings of (*a*) and (*b*) the requirements could be fulfilled; but under spacings (*c*) and (*d*) they could not be, since in the former the available floor-space per child is only 4 feet, and in the latter only $2\frac{2}{5}$ feet. It is therefore clear that in considering the dimensions of any room intended for occupancy, the relations between superficial and cubic space must bear a certain relation to one another with special reference to the possibility of adequate ventilation. This is true of all rooms, whether occupied by healthy or sick. In the latter case, especially, each dimension of space must be increased, and particularly in isolation hospitals, where the minimum superficial space ought not to be less than 144 square feet, and the cubic space than 2000 feet. The following tables show the cubic space required by law per person in certain conditions of life, and the school spaces which exist in different countries.

TABLE XXVIII

TABLE SHOWING CUBIC SPACE ALLOWED BY LAW

Cubic Space allowed by Law or Local Regulations	Cubic Space per Head	Authority
Board Schools under Education Act .	80	Education Act
Board Schools (minimum under New Code)	100	Education Department
General school-rooms . . .	130	London School Board
Graded schools	117	" "
Dundee Board schools—newest . .	152	Dundee School Board
Canadian schools	240	Canadian Government
Ordinary dwelling-houses in Glasgow and Edinburgh, in one and two roomed houses—for adult . .	400	Local Municipal Authority
Two children under 10 . . .	400	Local Municipal Authority
Common lodging-houses . . .	240–400	
Poor Law for healthy persons . .	300	
Poor Law for sick persons . . .	850–1200	
Barracks	600	Army Regulations
Army hospital wards . . .	1200	" "
Army Huts (free ventilation) . .	400	" "
Army Hospital	600	" "
Canal boats (persons over twelve .	60	Local Government Board Regulations under Canal Boats Act, 1877
Do. (persons under twelve) .	40	
Seamen's cabins	72	Merchant Shipping Act
Non-textile work-places . . .	250	Factory Act, 1901
Do. Do. (during overtime)	400	

By the Burgh Police (Scotland) Act, 1903, section 67 (adoptive), any person appointed in writing by the Town Council of a burgh may at any reasonable time enter any dwelling-house of not more than three apartments for the purpose of measuring in cubic feet the space contained therein (exclusive of lobbies, presses, closets and recesses), and if cubic contents thereof do not exceed 2400 feet may, in a manner determined by the Council, mark thereon or affix thereto a ticket on which are marked (1) the number of such cubic feet, and (2) the number of persons over ten years of age who may legally sleep therein, reckoning one such person for every 400 cubic feet; defacement or removal of the ticket to be followed by a penalty. Every two persons of less than ten years shall be reckoned as one person exceeding that age.

TABLE XXIX

TABLE SHOWING SCHOOL SPACES IN DIFFERENT COUNTRIES

Country	Superficial Floor Space in Square Feet	Cubic Space in Feet
Great Britain (Government Code)	10	100 to 140
London School Board	..	130
Dundee School Board	..	152
Canada	..	240
Belgium	10½	160
Belgium Educational League	17½	338
Holland (average)	..	131
„ Haarlem (average)	..	160
Bavaria (children of eight years)	..	137
„ (children of twelve years)	..	197
Dresden	7	152
Frankfort (Med. Society)	15½	300 to 325
Basle (Switzerland)	15½	148 to 165
Sweden (Primary schools)	16	188 to 266
„ (Higher schools)	17 to 23	271 to 352
America (New York City	..	88 to 105
Columbia (Commission)	15	210
Massachusetts (State)	Demands that each pupil receive 1800 cubit feet of warmed fresh air per hour	

Taken from a paper by the Author on "The Hygiene of Schools" in *The Sanitary Journal,* January 1895.

Effects of Occupation of Rooms, or other Confined Spaces.—If an ill-ventilated room be occupied for two or more hours, the following changes will be found in the composition of its air at the end of the term of occupancy—viz.

(*a*) The temperature will be raised; due to the heat from the bodies of the occupants, quite apart from any other source, as artificial lights;

(*b*) Watery vapour is increased in quantity; due to exhalation from the lungs and body-surface of occupants;

(*c*) Amount of carbonic acid gas per cent. will be increased;

(*d*) A disagreeable odour will be imparted to the atmosphere.

These facts are explained in the following :—An average male adult inspires 30·5 cubic inches of air at each breath, and he inspires about seventeen times per minute; the total quantity of air which he will breathe in 24 hours will, therefore, be the sum of the following calculation—viz.

$$30{\cdot}5 \times 17 \times 60 \times 24 = 746{,}640 \text{ cubic inches} = 432 \text{ cubic feet.}$$

Women and children use a less daily amount of air than this. The expired air, if we contrast its composition with that of fresh air, contains 101 times more carbonic acid gas than the latter, and further, it contains much watery vapour from the surfaces of the air-passages, varying in different persons at different times from 3½ to 45 ounces, or even more per 24 hours. In addition to these, organic débris in a state of incipient putrefaction is given off from the breath and bodies of the occupants, which imparts to the air of the room a close, disagreeable, or even foul odour. This expired air is thrown out of the body at a temperature about 100° F. The average adult gives off, in ordinary circumstances, at least ·6 of a cubic foot of CO_2 per hour, or 14·4 cubic feet per 24 hours.

The amount of carbon dioxide gas given off from the lungs depends, however, upon a variety of circumstances, such as work, or rest, and diet. The experiments of Pettenkofer and Voit show this. The total amount of this gas given off in 24 hours by a healthy person at rest was 716 grams, and by the same person at work, 1187 grams, at rest with ordinary diet, 928 grams, at work with ordinary diet, 806 grams, at rest with rich diet, 1020 grams, and at rest with a nitrogen-free diet, 839 grams.

If, in addition to human occupation, artificial lights be used in a room, the increase of temperature and of CO_2 are even greater. A gas-jet which consumes about 4 cubic feet of gas per hour produces about 2 cubic feet of CO_2 per hour; and in like manner acetylene, oil, and other illuminants contribute to the sum of this gas. As has already been shown, CO_2 exists in pure air to the extent of ·04 per cent. This is called the *original* or *initial impurity*. Any excess over that figure in the air of a room represents the amount due to respiratory and other causes, as artificial lights, and hence that is called the *respiratory* impurity. Both added together are called the *total impurity*. The odour of the air of a room depends upon the presence of organic matter, and the measure of its amount is indicated in three ways—viz. (1) by the sense of smell to a person coming into the room from the fresh air; (2) by the amount of CO_2 present and found on analysis; and (3) by direct estimation of the organic matter itself. When the proportion of the respiratory impurity of the total CO_2 in air is not greater than ·02 per cent., no disagreeable odour is perceived, but above that proportion odours become perceptible: thus ·08—*i.e.* ·04 initial + ·04 respiratory impurity, causes a stuffy odour; ·10 (*i.e.* ·04 + ·06), an offensive odour; and ·12 (*i.e.* ·04 + ·08), a foul, sickening smell. Beyond this point the sense of smell fails to discriminate. Moreover, in atmospheres containing these latter proportions of CO_2, flushings, faintness, headache, and even sickness are liable to be induced. The pernicious effects of foul air are doubtless attributable to the combined effects of excess of CO_2 and organic matter. It is impossible to discriminate between the effects produced by the operations of these singly, since from occupation of imperfectly ventilated rooms they are closely associated together. Most observers, however, are inclined to attribute the evil effects mainly to the organic matter which is given off from the bodies of occupants of a room, and which consists of varied materials, partly volatile fatty acids from the skin which are given off by the sensible perspiration, and in certain individuals and nations more markedly than in others, and also of intestinal gases and products of decomposition from soiled clothing. Of late years, however, certain investigators have arrived at the conclusion that these last are not so prejudicial to health as was believed, and indeed that the baneful factors in impure room air are chiefly excess of CO_2

and decrease of oxygen. The experiments of Haldane and Lorrain Smith indicate at least that immediate danger is caused by these factors, but they do not in our view weaken the conclusion generally held—viz. that constant exposure of air contaminated with organic matter is more contributory to the generation of lowered health and disease than the presence *per se* of excess of CO_2. There can be little doubt that where persons are more or less constantly exposed to atmospheres containing fractional proportions of carbon monoxide, or of coal-gas, ill-health, as exhibited by anæmia, malnutrition, and other symptoms, will quickly supervene, owing to the union of this gas with the hæmoglobin of the blood, and to its crippling action upon the function of the blood-corpuscles to carry oxygen to the tissues. That organic matter is particulate, in part at least, is demonstrated by the fact that articles of attire retain the disagreeable odour for some time after exposure to fresh air, and that bedclothing in such a room retains it for a very long time. The painstaking investigations of Billings, Mitchell, and Bergey,[1] confirmatory of the experimental results of other observers, led these observers to conclude, (1) that in air expired by man there is no peculiar organic matter which is poisonous to mice, sparrows, rabbits, or guinea-pigs, and that it is improbable that the minute quantity of organic matter expired from human lungs is hurtful to those inhaling it in ordinary rooms; (2) that the ammonia, combined nitrogen, or other oxidisable matters found in the condensed watery vapour of expired air of man probably arises from decomposition of organic matter in the pharynx and mouth; (3) that the results should be more properly ascribed to the diminution of oxygen and increase in carbonic acid gas; and (4) that the cause of the disagreeable odour which is perceptible in ill-ventilated, occupied rooms is not precisely known, but is probably due to volatile products given off from the mouth and skin, and from soiled clothing. In order to maintain health, therefore, it is essential that the amount of CO_2 should be kept as near ·06 per cent. as possible, of which ·04 is initial, and ·02 respiratory impurity.

VENTILATION

In order to maintain purity of air in inhabited rooms it is essential, therefore, that the fouled air should be got rid of to give place to the fresh air. This is effected by means of ventilation. *The problem of ventilation consists in supplying in a given space to a given number of persons in a given time the necessary physiological amount of fresh air without draught.* Physiological requirements indicate 3000 cubic feet of pure air per hour as the supply to be aimed at, and the rate of movement of the incoming air must not exceed 1½ to 2 feet for delicate persons, and for average persons 2½ to 3 feet, per second, else draughts will be perceived. Should the air be warmed, however, the velocity may be raised to 5-8 feet per second. This is the crux of the problem of ventilation, and hence the dimensions of space per person in a room assume great importance. When the Glasgow Sanitary (Further Powers) Bill was before a Parliamentary Committee, it was contended as a reason why the cubic space per person should be raised from 300 to 400 cubic feet, that the possibility of ventilating such small one- and two-roomed houses might be realised. As a matter of fact, however, while ventilation might be improved in the better of these conditions it could not adequately be carried out, as the following figures will show. An average-sized one-roomed house contained 1060 cubic feet. Under the previous Act, it was entitled to house three adults and one child.

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[1] "The Composition of Expired Air and its Effects upon Animal Life," p. 24.

As each adult requires 3000 cubic feet of air

∴ $3\frac{1}{2}$ adults × 3000 . .	=	10,500 cubic feet.
At night, with an ordinary gas-jet burning 3–4 cubic feet of gas, the air-supply needed for that	=	6,000
Total	=	16,500 cubic feet required per hour.

The air needed per hour being 16,500 cubic feet, and the cubic capacity of the room 1060 feet, it is obvious that the air of the room would need to be changed—16,500 ÷ 1060—say, 15 times per hour; in other words, 1060 cubic feet would require to enter in four minutes, or 4·4 feet per second. This rate of velocity produces draughts, to prevent which the inlet openings are blocked up by the occupants. Under the proposed alteration to 400 cubic feet per adult, and half this amount for a child under twelve, the rate of velocity, all other things equal, would only be reduced to about 3·8 feet per second. Again, if we suppose two rooms, each of 1000 cubic feet capacity, to be occupied as bedrooms by one and by four adults respectively, a little calculation will show that in the case of the former the necessary amount of air could be supplied to fulfil the physiological needs of the individual and without draught, since the air would enter at a velocity of ·8 of a foot per second, but that in the latter the supply of the requisite amount of air would be accompanied by draughts, since the velocity of the entering air would be over 3 feet per second.

The amount of CO_2 being then a measure of the impurity, organic and inorganic, of the air of an occupied place, and the amount of this gas normally present in pure air being known, by an estimation of its quantity in the air of any given room it is possible (1) to determine the volume of air which is being supplied to the room, and (2), if it be inadequate in volume, to what extent the inadequacy prevails. Du Chaumont's formula is as follows:—

Let p = amount of CO_2 present in one cubic foot of pure air;
P = amount of CO_2 in terms of a cubic foot given off by each average person per hour;
A = amount of air in cubic feet required, or introduced per hour, the same amount escaping by outlets;
π = impurity of the air in terms of CO_2 which results.

Known by estimation:

p = ·04 per cent., or ·0004 CO_2 per cubic foot in pure air;
P = ·6 cubic foot CO_2 in expired air per person per hour.

From these factors two formulæ may be constructed:

1. To determine the volume of air per hour in cubic feet required by each average person in order to maintain respiratory impurity at ·02 per cent.
2. From the CO_2 found, to ascertain the amount of fresh air which is delivered to each occupant per hour.

For the first calculation the formula becomes—

$$A = \frac{P}{\pi - p} = A = \frac{\cdot 6}{\cdot 0006 - \cdot 0004} = 3000 \text{ cubic feet per hour.}$$

But p being practically a constant, the formula may be shortened as follows—viz.

$$A = \frac{P}{p}$$

$$A = \frac{0{\cdot}6}{\cdot 0002} = \underline{3000} \text{ cubic feet per hour.}$$

Three thousand cubic feet of air per hour, therefore, is the amount required by the average adult person to maintain the total impurity in the air of a room at the healthy minimum, in terms of CO_2—viz. ·06 per cent., of which ·04 is original impurity, and ·02 respiratory impurity.

Example.—A room of 1000 cubic feet capacity is occupied by five adults for four hours: it is required to find the total amount of CO_2 per 1000 vols. of air at the end of that time, on the assumption that during the time of occupation 5000 cubic feet of fresh air per hour have been supplied.

In this problem the values of A, P, and p are given, and what is required is to find the value of π, the permanent impurity:

$$\text{Value of } A \begin{cases} \text{cubic capacity of room} \quad . & = 1{,}000 \text{ feet.} \\ \text{air supplied during the time,} & \\ \quad 5000 \text{ feet} \times 4 \text{ hours} \quad . & = \underline{20{,}000} \end{cases}$$

$$\text{Total} \quad . \quad = 21{,}000 \text{ cubic feet.}$$

Value of P: $0{\cdot}6 \times 4 = 2{\cdot}4 \times 5$ persons $= 12$ cubic feet CO_2.
= amount of CO_2 contributed by five persons during four hours' occupancy.

$$\therefore \frac{P}{A} = \frac{12}{21{,}000} = \cdot 00057 \; CO_2 \text{ per cubic foot of air of room, or}$$

$$= \cdot 00057 \times 1000 = \cdot 57 \text{ parts } CO_2 \text{ per 1000 cubic feet.}$$

But $p = \cdot 4$ parts of CO_2 per 1000 vols. of pure air which is supplied.
Therefore, $\pi = \cdot 57 + \cdot 4 = \cdot 97$ parts CO_2 present in air of room; or the resulting permanent impurity.

The second use of the formula is to determine from the CO_2 found the amount of fresh air which has been delivered during a given time to all or each of the occupants of a room per hour.

Example.—The air of a room occupied by five adults is found to contain 9·7 vols. of CO_2 per 10,000 vols. of air: it is required to find the total amount of fresh air supplied per hour, and the amount to each occupant.

The problem here is to find the value of A.

$$A = \frac{P}{\pi - p}.$$

Value of $P = 0{\cdot}6 \times 5 = 3$ cubic feet of CO_2 of respiratory impurity given off by five persons during one hour ;

,, ,, $p = 0{\cdot}4$ CO_2 per 1000 cubic feet of air ; or ·0004 per cubic foot.

,, ,, $\pi = 0{\cdot}97$ CO_2 per 1000 cubic feet of air ; or ·00097 per cubic foot.

Therefore, $A = \dfrac{3}{{\cdot}00097 - {\cdot}0004} = 5263$ cubic feet for five persons ;

or, $5263 \div 5 = 1052$ cubic feet per person.

Another common formula in use is—

$$D = \frac{E}{r}.$$

Where D = delivery, or amount of fresh air available in cubic feet ;
E = amount of CO_2 given off ;
r = respiratory impurity in terms of CO_2 per cubic foot.

The analyses of Carnelly and others of the air of sleeping apartments during early hours of the morning show (1) that the quantity of CO_2 has a distinct relation to the amount of air supplied to the apartment. It amounted from 0·79 vols. per 1000 of air, where the air-supply per head was between 2500 and 4000 cubic feet, to 0·92, where the supply was from 340–500 cubic feet, and up to 1·15 per 1000, where the supply was so low as from 100 to 180 cubic feet ; (2) that the organic matter, estimated in terms of oxygen required per million volumes of air, with the same supplies of air as above, was 5, 8·4, and 15·1 parts per million respectively ; and (3) that the number of microbes per 1000 c.c. of air was 13, 42 and 80 respectively. These Dundee experiments make abundantly clear that in one-, two- and three-roomed houses the impurity of the atmosphere must operate as an important factor in the causation of disease and death.

METHODS OF VENTILATION

All schemes of ventilation are separable into two divisions, depending upon the motive power which originates them. In the one division, the motive power is found in the ordinary forces of nature, in the other, it takes the form of some kind of artificial mechanical power or aid. Ventilation produced by the forces of nature has been called *Natural* ventilation, that by mechanical or artificial power, *Artificial* or mechanical ventilation. The line of division must not, however, be pushed too closely, for reasons which are bound to emerge.

Natural Ventilation is produced by the operation of the following laws of gases—viz.

(*a*) By the law of diffusion of gases, established by Graham—viz. that the relative velocities of diffusion of any two gases are inversely as the square root of their densities. Taking hydrogen as unity, the density of CO_2 is 22·08, the square root of that being 4·7, whence hydrogen in a medium like air will diffuse 4·7 times as rapidly as CO_2 ; in other words, its velocity of diffusion is 4·7 times greater. The atmosphere,

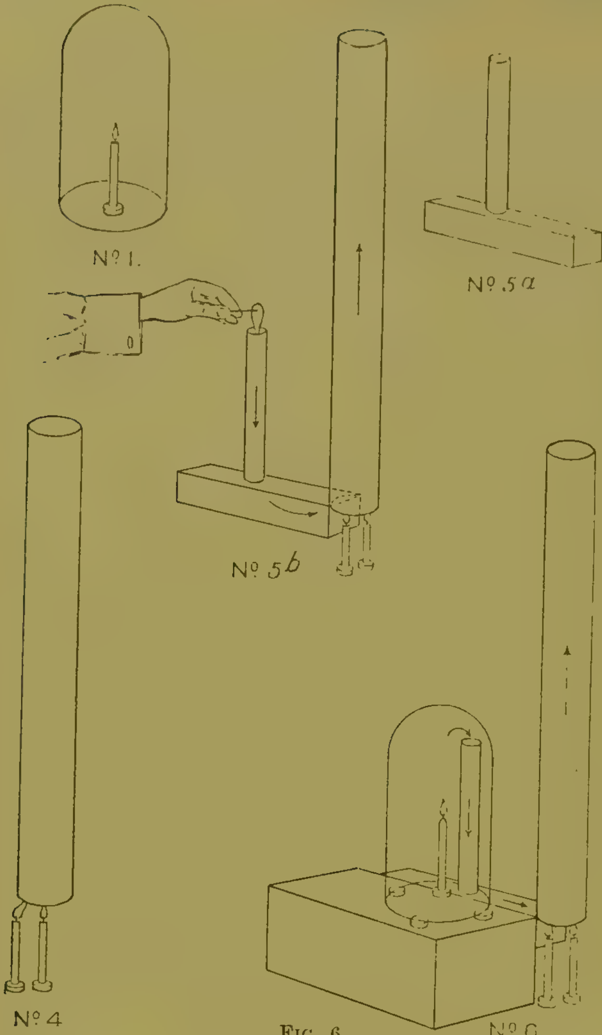


FIG. 6.

Apparatus for experimenting on the Principles of Ventilation. No. 1 is an ordinary thin-glass bell-jar and lit candle; No. 4, a cardboard funnel to show production of up-draught; No. 5*a*, a cardboard box with small cardboard funnel attached, both made airtight; a small semi-lunar opening being made at one extremity of the box; No. 5*b* shows the effect upon a flame when Nos. 4 and 5*a* are fitted together; No. 6 shows these, with the addition of No. 1 slightly raised and standing on a box, fitted together. The last experiment illustrates the principles of Ventilation by Exhaustion or Extraction. *First Experiment.*—To prove that combustion or respiration will cease when air-supply is cut off. Under the bell-jar (No. 1) place a lighted candle. The light goes out when the air-supply of the bell-jar is used up. *Second Experiment.*—Place the bell-jar on a flat surface and raise it at three points by three pennies or thin pieces of cork. The lighted candle will again go out, because there is no movement of incoming air in the bell-jar. *Third Experiment.*—Place No. 4 and No. 5*a* in relation to one another as at No. 5*b*; place the candles as in No. 4; apply a piece of smoking brown paper, or a taper at the top of the smaller funnel, when it will be seen that the smoke is carried down the funnel through the box, in the direction of the arrow into the larger funnel. *Fourth Experiment.*—Place the pieces of apparatus already described as in No. 6. Light one or more candles under the bell-jar, and under the large funnel. The candles under the jar will burn brightly, because a movement of air is set up from beneath the bell-jar, down the smaller funnel, through the cardboard box and up the larger funnel; thus demonstrating that the foul air formed in the bell-jar is being constantly carried away.

therefore, composed of a mechanical mixture of gases, being subject to this law, tends towards uniformity of composition;

(*b*) By the motion which is set up between two columns or bodies of air of different temperatures and pressures. The law of Charles is that a gas when heated, the pressure being constant, increases in volume to the same extent, whatever the gas may be. Guy-Lussac's law is that the volume of one and the same gas varies with the temperature; and Mariotte's law, that the density of one and the same gas is proportional to the pressure. The amount of expansion of a gas for each degree of increase of temperature is at once definite and determinable. One volume of a gas at 0° C. becomes 1 + ·003665 at 1°, or, in other words, increases by $\frac{1}{273}$ part of its volume; for every degree Fahrenheit above 32°, ·002, or $\frac{1}{491}$ part of its volume. Boyle's law for pressure is that the volume of a given weight of any gas is inversely as the pressure, where 760 millimetres of mercury is taken as the standard pressure.

(*c*) When a wind blows across a ventilating shaft or a chimney, or past a window, a partial vacuum—in other words, a reduction of pressure—takes place in the shaft, chimney or room, and a consequent increased upward or outward movement of air takes place. This action is called *perflation.*

A cubic foot of air at 32° F., and under a pressure of 29·92 inches of mercury, weighs 0·081 lbs. From this datum the weight of a cubic foot of air at any temperature may be calculated from the formula:

$$W = \frac{\cdot 081}{1 + (0{\cdot}00204 \times (t - 32°)}.$$

Thus, suppose the temperature of the air at 32° F. is raised to 70° F., to find the weight at the higher temperature:

$$W = \frac{0{\cdot}081}{1 + (0{\cdot}00204 \times (70 - 32)} = W = \frac{\cdot 081}{1{\cdot}077} = 0{\cdot}0752 = \text{weight at } 70° \text{ F.}:$$

Mechanical Ventilation.—All schemes of this class are also subject to division into two classes—viz.

(*a*) That in which the pure air is forced or propelled into the place to be ventilated under slight pressure, and hence has been denominated the *Propulsion* or *Plenum* method;

(*b*) That in which the foul air is extracted—the fresh air entering at prepared inlets—hence the name of *Extraction* or *Vacuum* Method.

Natural ventilation obtains in the average ordinary room in which the main available means of ventilation are (1) door, (2) window, (3) fireplace, not to speak of adventitious chinks in the flooring and walls of the apartment. With a live fire in the grate, the two former act as inlets, the latter as the outlet. A small grate will exhaust from the room supply from 3 to 5 cubic feet per second—that is, from 10,800 to 18,000 cubic feet of air per hour—and an ordinary grate, from 5 to 8 cubic feet per second, or 18,000 to 28,000 feet. To supply these amounts air rushes in by window, or windows and doorways, and by any other available source. In the atmosphere of the ordinary room there are practically two strata of air, the lower reaching from the floor-level to the level of the artificial lights, the upper from the lights to the ceiling. The lower is the colder, because the entering cold air strikes a line between doorway and window and fireplace; the upper contains a column of relatively stagnant air, which is, usually, several degrees higher in temperature. Where there is no fire in the room the heat from the bodies of the occupants determines air-movements. According to the law of temperature of gases, the rate of velocity of inflow of air into the room is relative to the difference between the temperature of the outside and inside air; the greater the difference, the higher the velocity.

Methods by which Room Ventilation may be improved.—Different methods have been suggested whereby the entrance of fresh, and the exit of foul, air may be rendered more uniform and more certain.

These have been applied to (*a*) Windows, (*b*) Walls, and (*c*) Chimney of the room.

Window Ventilation.—The plan of Hinckes-Bird is very simple, and may be applied to any sash window. It consists in placing at the bottom of the window a block of wood of the exact width of the sash, and which may vary in thickness, on which the lower sash will rest. This causes the sashes to be separated at their junction, and enables air to pass from without inwards by the space created. (Figs. 7 and 8.)

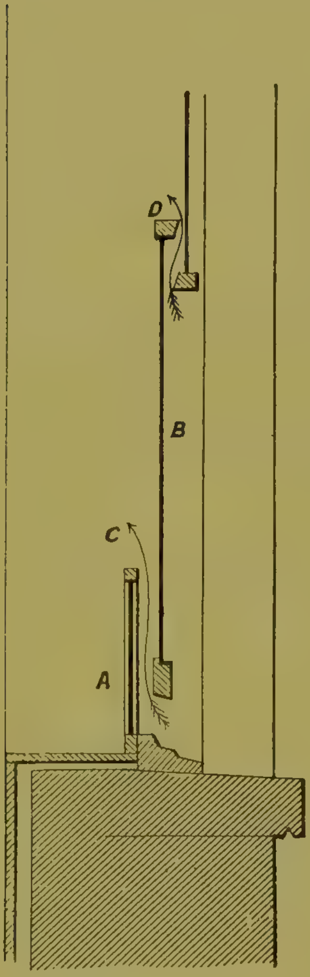


Fig. 7.—Mode of Ventilation by Window. *A*, glass-plate on inside of lower sash to prevent direct draught; *C*, direction of incoming air from beneath open lower sash; *D*, raised part of lower sash, forming interspace at junction of sashes and direction of incoming air.

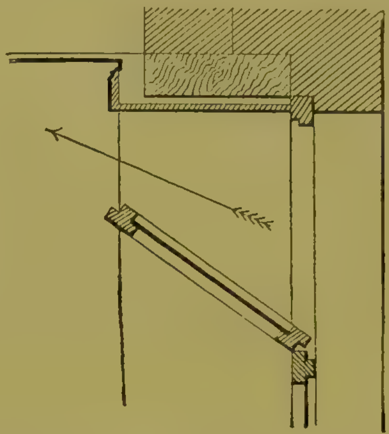


Fig. 8.—Window Ventilation by hinged frame in upper part of upper sash.

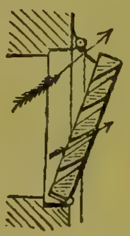


Fig. 9.—Mode of Wall Ventilation, by hinged perforated wooden brick. By opening or closing brick the amount of entering air can be regulated, while when closed, ventilation proceeds by the air-holes.

Another method is to affix a metal plate of zinc along the top of the window, which enables the upper sash to be pulled down sufficiently to produce an interspace at the junction of the sashes. Other methods, such as holes in the lower part of the upper sash, perforated panes, and double-glazed panes, where the outer pane has a bottom gap and the inner an upper gap, have been suggested, but they are objectionable in smoky atmospheres, because of "smuts" and dust collecting in the interspaces or openings. Double-sashed windows have also been tried. Better methods, however, are those by which Moore's louvre, or circular glass ventilator, is fitted into the window-frame as a substitute for a pane.

Another excellent method is to substitute for the upper half of the window, or a part of it if large, Hatton's hopper window-ventilator. This not only serves the purpose of a window-sash, but acts as a ventilator, and when so acting, not only prevents direct draught, but screens the air from particles.

Other methods are applicable to the sashes themselves. The following figures show some suggested by the writer. (Fig. 11.)

The above are photographs of four-feet-long working models. Fig. A may be made to act as an ordinary sash window, or the upper sash may be made to act as a hopper-ventilator, as shown in the figure, or the lower sash as a hinged window, as in Fig. B. This is attained by sunk movable hinges in the side of window-frame. By means of these movements, differing amounts of ventilation, depending upon outside weather conditions, may be obtained, and besides, the window may be wholly cleaned by a domestic from the interior of the apartment.

One of the best forms of ventilating windows for institutions, such as hospitals, unions, hotels, schools, etc., which has been devised during recent years is the Chaddock window. The principle of the window is that all its parts are controlled by a single action, and the degree of ventilation desired may, therefore, be regulated. The opening and shutting of its sashes are worked by a rotatory-acting, removable handle. When the handle is turned, the first effect is to open gradually the upper sash as a louvre or hopper to any degree required, and, by continuing the rotation of the handle, to cause the larger lower sash to swing open on its central pivot. By the one movement, therefore, the amount of ventilating space opened is completely under control, nor can the position of the window now be changed if the key-handle be removed. From a careful examination of the mechanism of the window, and inspection of it after use in a school for over a year, its advantages would seem to be as follows:—(*a*) the controlling movement is easy to work; (*b*) all the opening movements of the sashes are regulated and controlled by the one and the same action; (*c*) the ventilation of any room can, therefore, be adjusted to suit different conditions of weather; (*d*) cleaning of the window is accomplished from the interior of the room; and (*e*) the parts of the window are weathertight. (Fig. 12.)

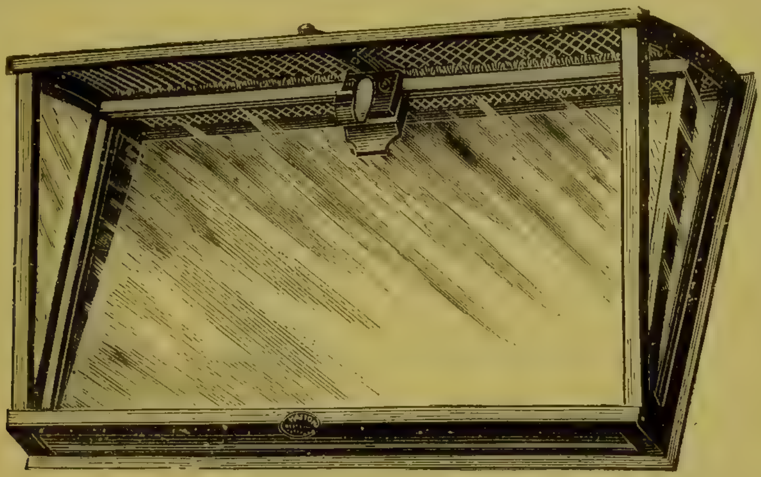


FIG. 10.—Hatton's Hopper Window-Ventilator. The amount of incoming air is regulated by the extent of opening the hopper, and is screened of soot particles by the fine copper gauze shown at top of figure. This soot is brushed away by the brush seen working against the gauze.

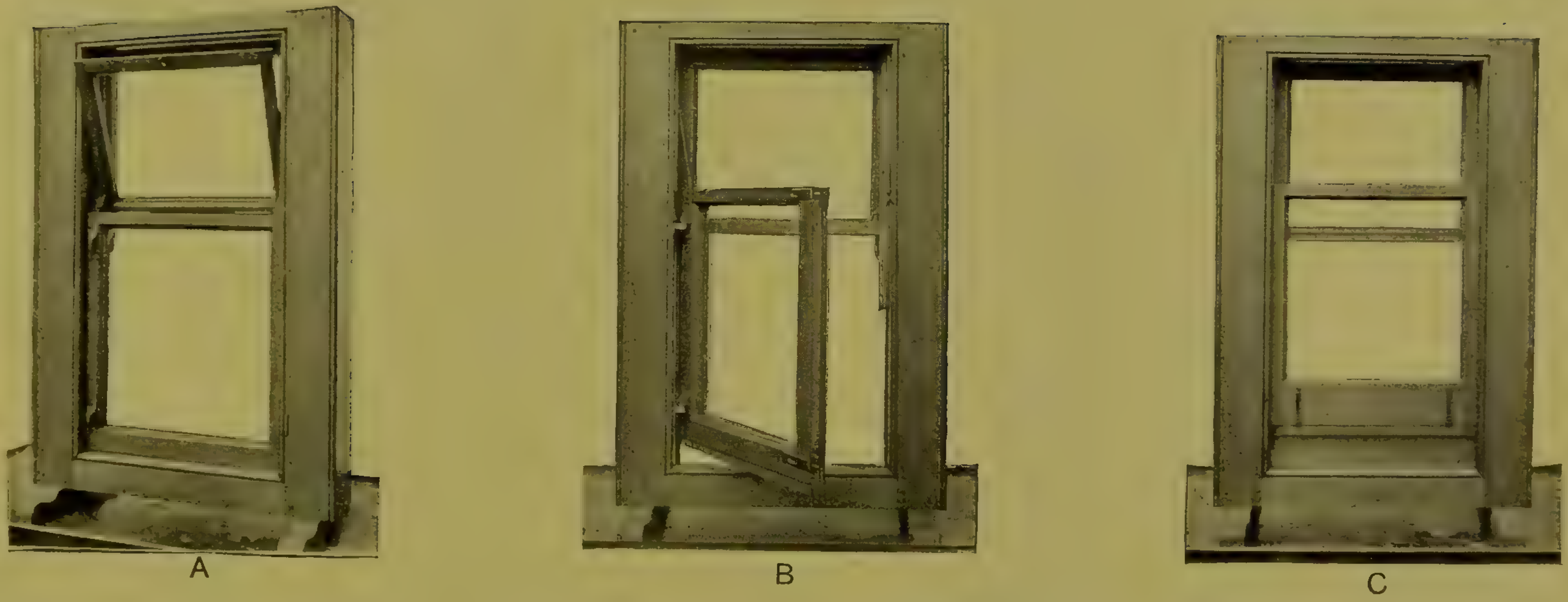


Fig. 11.—To show new methods of window ventilation suggested by the author.

The above are photos of four-feet-long working models for teaching purposes. Fig. A may be made to act as an ordinary sash window with up-and-down movement; or the upper sash to act as a hopper, as shown in A; or the lower sash to act as a hinged window, as in B. This is effected by means of sunk movable hinges in side of window-frame, the sockets of which are screwed into side of sash. By means of these two movements, therefore, differing degrees of room ventilation, according to weather, may be obtained, and besides the whole window may be cleaned by a servant from the interior of the apartment. C shows the author's modification of the Hinckes-Bird arrangement. In the latter system a series of blocks of different thickness is required to regulate the amount of inter-sash ventilation on account of weather. In the author's plan one block, which is always at hand, serves for all weathers. This is effected by counter-sinking into the lower frame of the lower sash a movable teak block, which may be lengthened or shortened by means of two screws working in brass slots. When this block is pushed "home" it is "flush" with the level of frame.

Wall Ventilation.—The special forms of ventilators applicable to outside walls of apartments are: (*a*) Sheringham's valve; (*b*) Hatton's screen valve; (*c*) Tobin's tube. Placed in an outer wall, the one end communicates with the outer air, the other with the interior of the room. In the two former, the amount of entering air is regulated by the extent to which the hopper is opened; in the latter, by a screen in the throat of the tube. (Figs. 13, 14.)

Tobin's tubes are of various forms. Their internal opening is placed from six to seven feet from the floor. Some possess a drawer, containing cotton wool for the purpose of filtering the incoming air. (Figs. 15, 16.)

Chimney Ventilation.—Dr Arnot, seeing the motive power which existed in the heated air of the chimney for extracting the foul air from the upper levels of a room, was the first to place in the wall of a room a valvular opening which connected the interior of the room with that of the chimney. (Fig. 17.) Owing, however, to the defective character of the fittings which permitted soot to be driven into the room by back-draughts in the flue, it was for a long time given up. But when workmanship improved and valves of mica were used, the chimney valve was revived. Those of Boyle and Buchan are in common use. The valves are so constructed that they only permit of air passing from room to chimney, consequently they act only as outlets. Such a ventilator, when well fitted, is a most efficient and useful outlet, and its position is just where an outlet is most needed.

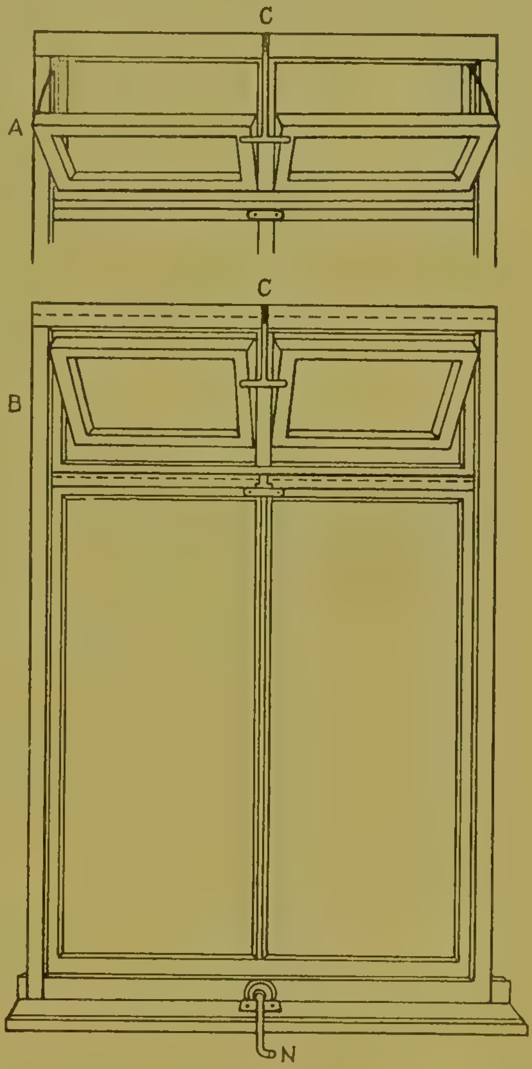


FIG. 12.—The Chaddock Window. By turning the handle of the lever N, the louvre or hopper sash at top of window, B, A is opened by the action of the rod C to any angle desired, and is fixed in position. The sash may be fitted as a hopper, as in A, or as a louvre, as in B. By turning the lever handle still further, the lower sash of the window may be swung open, when the room may be flushed with air; and by still further turning the lever, this sash may be swung into a position at right angles to the window-frame. The whole window may be closed weathertight by reversing the movement of the lever-handle.

But methods have been devised, with some success, to utilise the spent heat of the fireplace itself as a means of supplying fresh warmed air to a room. By means of a special duct which either surrounds, or is in close proximity to, the source of heat, the ingoing fresh air is warmed, and is passed into the apartment either at the level of the ceiling, in the wall, or close to the fireplace. Of these Galton's

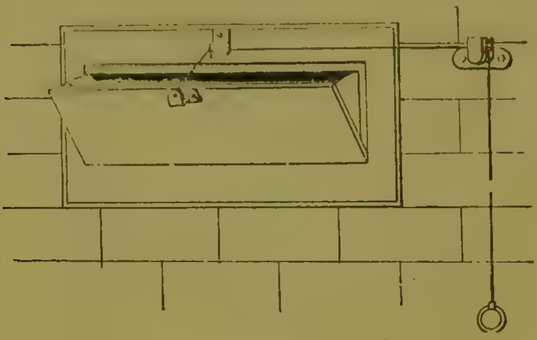


Fig. 13.—Sheringham's Valve.

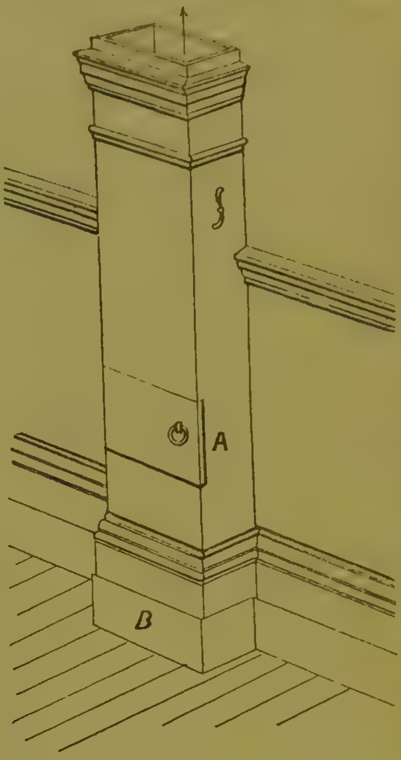


Fig. 15.—Tobin's Tube. By means of the opening at A, the tube may be periodically cleaned, and by means of the handle on the right side of the tube, which acts on a valve in the throat of the tube, the amount of incoming air may be regulated.

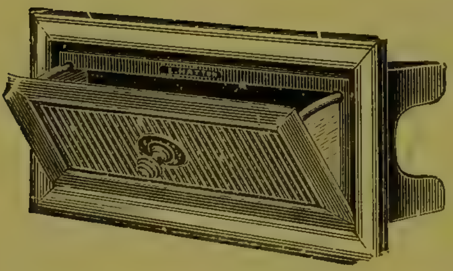


Fig. 14.—Hatton's Screen Valve. In this valve the air is screened on entering by means of fine copper gauze, and the gauze is kept clean of particulate matter by a brush which works on the gauze as the valve is opened and shut.

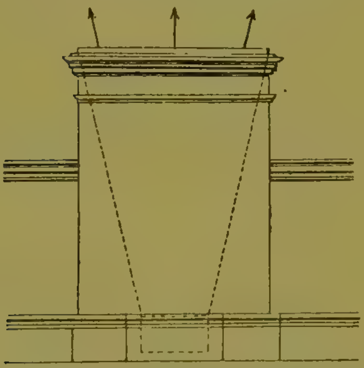


Fig. 16.—Another form of Tobin's Tube. This is shorter than Fig. 15, and is based on the principle that a current of air passing in a confined channel from a narrow point to a broader loses velocity. In this form of tube, although air may be entering rapidly at the contracted throat, it has lost all its harmful effects before it reaches the broader part at the top of the tube.

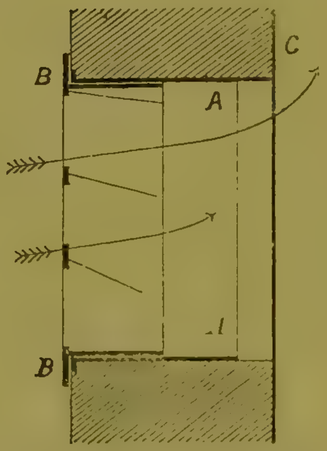


Fig. 17.—Chimney Valve. *B*, *B*, inner wall surface; *A*, *A*, valve-box; *C*, chimney. The arrows indicate direction of currents of air.

stove, George's calorigen, Bond's thermohydric stove, and the Canadian school stove may be considered as types. (Figs. 21, 22.)

For single-storeyed buildings, as churches, halls, schools, and other large buildings, or for apartments in the uppermost storey, roof ventilators have been devised, and the system has come to be known as *Roof-Ridge or Cowl Ventilation.* These roof-ridge appliances are either fixed or movable, and depend for their ventilating action upon the difference in pressure inside and outside a building, caused by the wind passing by and through them. (Fig. 23.) From the roof-ridge ventilator passes downward to the roof or ceiling of the building a shaft, which contains in its throat a valvular arrangement with silk valves which acts only in one direction —viz. toward the open air. The merits of this system of ventilation are (1) its comparatively cheap cost of installation; (2) its automatic action; and (3) its efficiency under suitable circumstances. Since in this country, barring very exceptionally short intervals of time, the wind seldom moves with a less velocity than 20 miles an hour, the perflating action is likely to be sufficient, provided the capacity of the ventilating shaft is adequate for the place to be ventilated. The chief objections which may be urged against the system and the mode of installation are these: (1) its inconsistent action; (2) derangement of the valves from clogging with dust, and thus permitting down-draughts; (3) the insufficient size of the ventilating shaft for the work it is expected to perform. The following figures show the *modus operandi* of the ventilator and shaft. (Figs. 24, 25.) Such cowl arrangements have largely superseded the use of Mackinnel's tube, which is fitted on the roof-ridge like the fore-

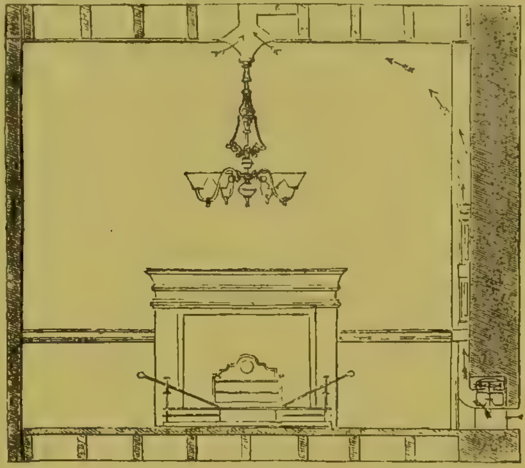


FIG. 18.—Ventilation of Room. Air enters at bottom of wall on right of figure, where it is washed by a rotatory spray of water, and passes into the room by a Tobin's Tube. The foul air is extracted by a hollow tube in the ceiling above the gasalier, the heat of the gas being the extractive motive power.

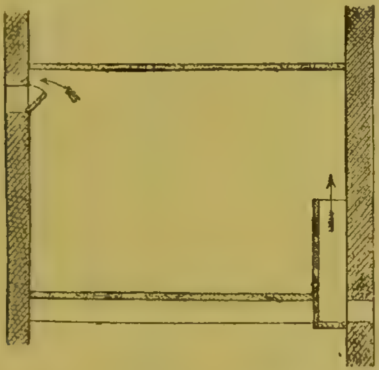


FIG. 19.—Tobin Tube and Sheringham Valve in position.

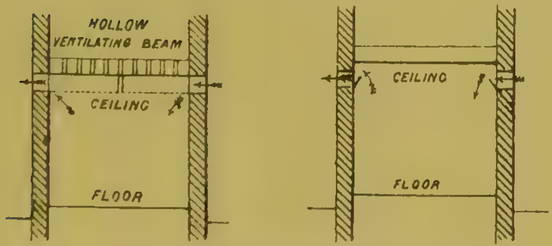


FIG. 20.—Other modes of ventilating rooms.

going, but differs from them in that it consists of two tubes, one inside the other, which pass downwards to the ceiling-level. The inner tube, which outside projects above the outer, and inside, below it, serves as the outlet shaft for foul air. At the ceiling end of the inner tube is a broad flange or rim which is intended to deflect along the ceiling the cold air passing downward by the outer tube before it falls into the apartment. In order that this apparatus should do the work intended, the sectional area of the space between the inner and outer tubes must be equal to that of the inner tube. In buildings such roof-ridge apparatus may be made to act as an outlet ventilator when it is most required, by lighting a sun-light gas burner or Bunsen flame placed almost immediately beneath it.

From a consideration of these methods, it will be observed that ventilation may be effected by natural forces solely, or by these aided by artificial openings. It will further be perceived how unwise it would be to make the line of division between natural and artificial ventilation too arbitrary.

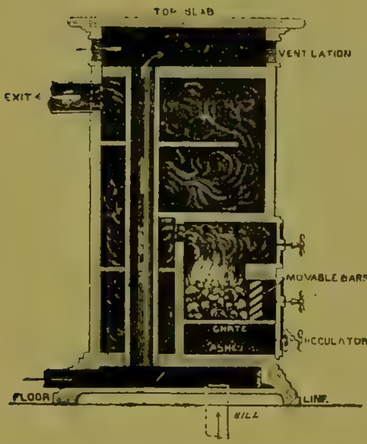


Fig. 21.—To illustrate one form of warming fresh air by a stove before admission to a building.

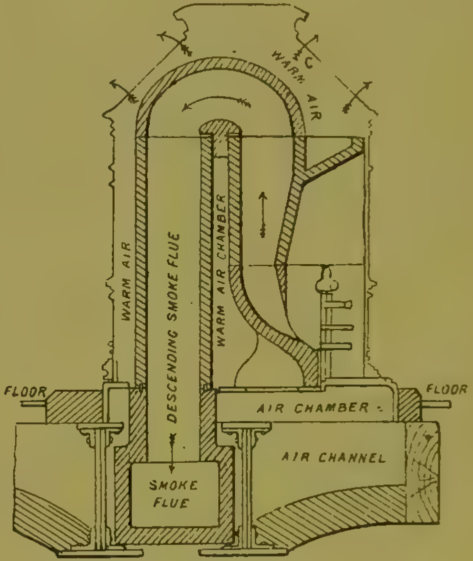


Fig. 22.—Another form of supplying fresh warmed air to a room. Section of Stove. (Rossie and Russell's Centre Grate.)

Mechanical Ventilation.—It may be said that ventilation of large buildings of complex design cannot be effected without recourse to some form of mechanical ventilation, and that in the employment of any such scheme warming of the air to be supplied must form an essential and integral part. When these are combined, and when the scheme is installed as part of the architect's or ventilator's design during the construction of the building, adequate quantities of warmed air may be supplied. In populous places, whatever be the scheme employed, it is essential that the air to be supplied must be screened as free as possible of particulate matter. In the system of ventilation adopted in the chemical laboratory of University College, Dundee, the air is screened by being passed through jute cloth which is stretched on frames seventeen feet long by four in width. During seven weeks' operation, the amount of particulate matter arrested on the screens weighed 2½ pounds. Where such screening is not employed, much particulate matter is swept into the ventilating ducts and the apartments. Any one acquainted with a large library or museum, where in the ventilating apparatus screening of the air does not prevail, knows the huge amount of impalpable fine dust which collects on books and objects of interest.

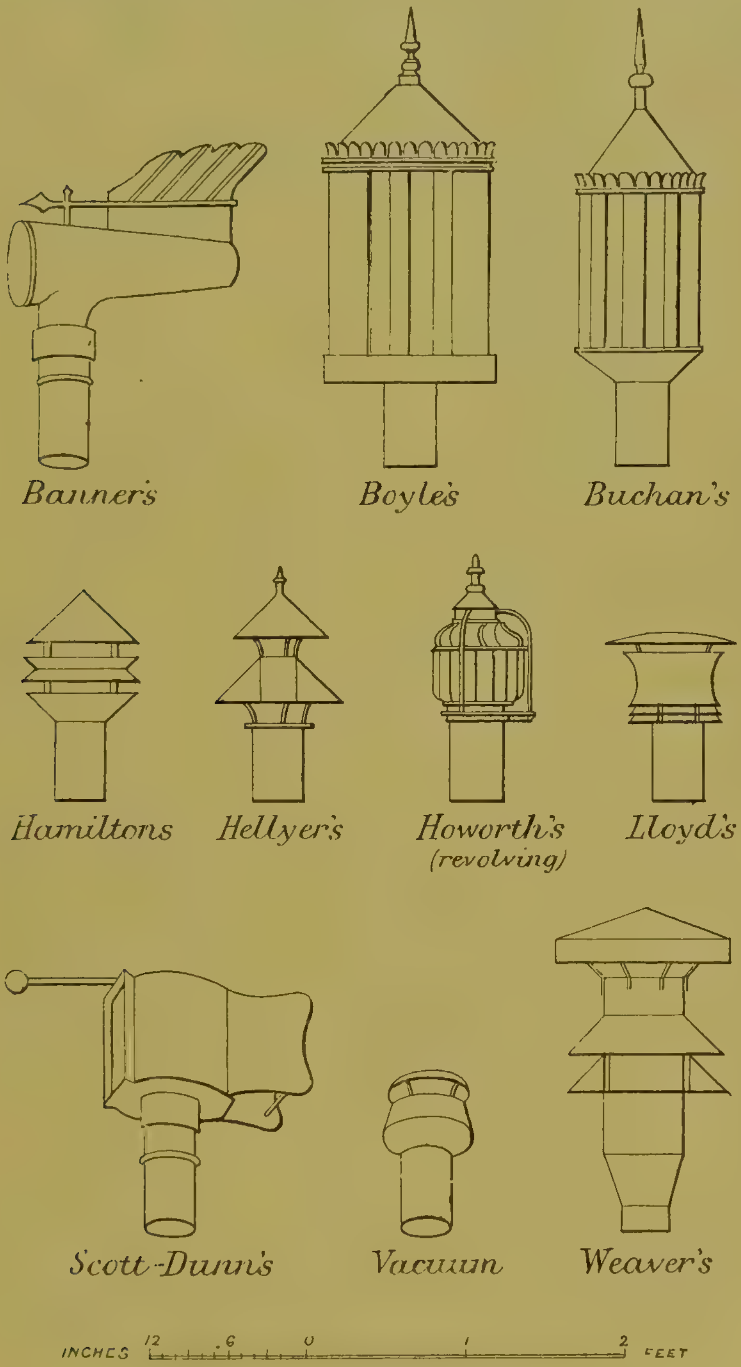


Fig. 23.—Forms of Ventilating Cowls.

Schemes of mechanical ventilation are divisible into (1) those in which fresh air, washed and warmed, or warmed without washing and screened dry, is propelled into the building, and the foul air driven out by special ducts or channels; and (2) those in which the foul air is extracted, the fresh air entering by inlet-channels to fill its place.

In the former system—*Plenum System*—the motive power acts at the beginning of the air circuit, and in the latter at its end. In the former, the motive power must be some form of mechanical force, such as a fan; in the latter, it may be a fire or a furnace in connection with a tall shaft, or a fan. Much has been written of the respective merits of both systems. From careful observations of both systems during some years, we believe efficiency to be on the side of the propulsion or plenum system, because of the reliability and steadiness of its action. In the plenum system originated by Key, the air is first washed and screened, is warmed, and is then propelled into the various rooms of the building. The washing is effected by causing the air to pass

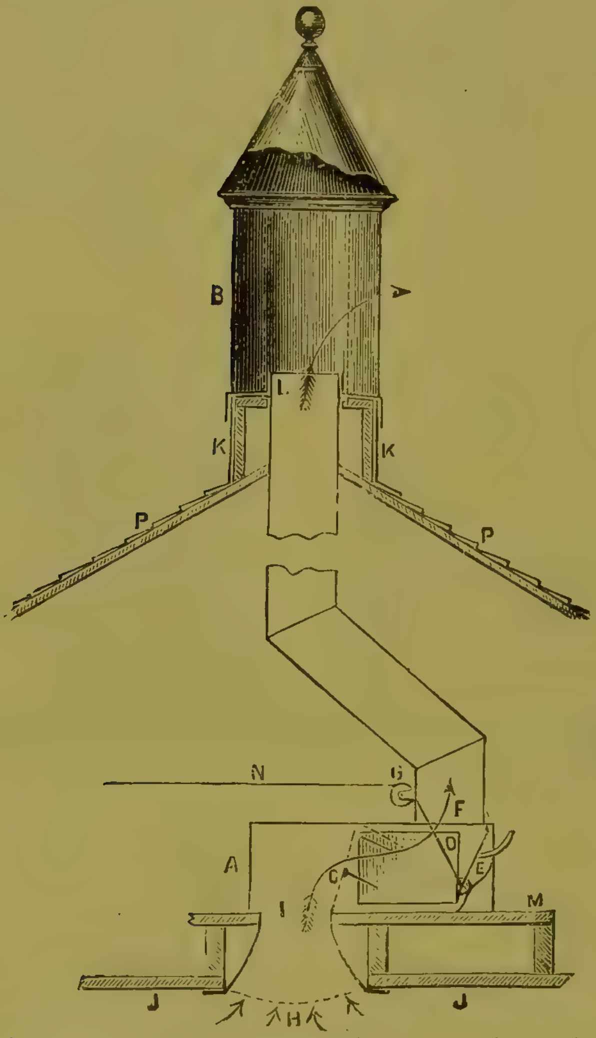


Fig. 24.—Buchan's Induced Current Fixed Ventilator. A, Valve-box; B, Fixed Ventilator; C, Silk Valve; L, Shaft; H, Grated opening in ceiling of building; J-J, Ceiling.

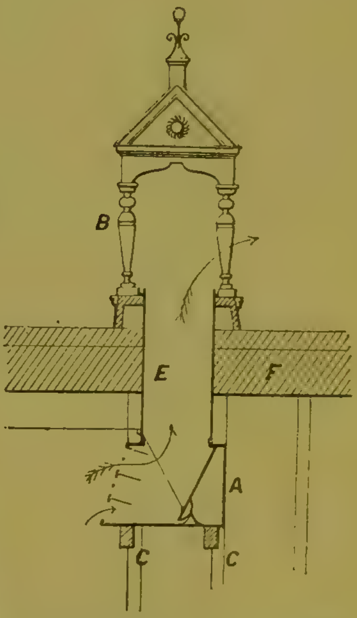


Fig. 25.—Simpler form of Roof-Ridge Ventilator. A, Valve-box; B, Fixed Ventilator. E, Air-shaft. Arrows indicate direction of air-current.

through a closely woven screen, composed of copper wire and fibre which is constantly kept trickling wet from a trough at its upper edge, the water in which is kept from freezing in winter by a steam-coil; the heating by coils of steam-piping behind the screen, and by subsidiary coils in the basement ducts; and the propulsive power by a large fan. In order to make the system effective, the doors to each apartment must be doubled, the windows kept closed, and there must be no chimneys in the rooms. Of both this and the extraction system it may indeed be said, that the nearer the building to be ventilated is kept liked a closed box with only two sets of openings, the more efficient is the ventilation. In the plenum system, the warmed air enters each apartment near the ceiling-level, and after it has served the needs of the occupants, the fouled air passes out by outlets placed at or near the floor-level. This it does by virtue of the measure of pressure with which it is propelled. This system is in operation in various large buildings in Glasgow, in the Birmingham General Infirmary and elsewhere. (Fig. 26.)

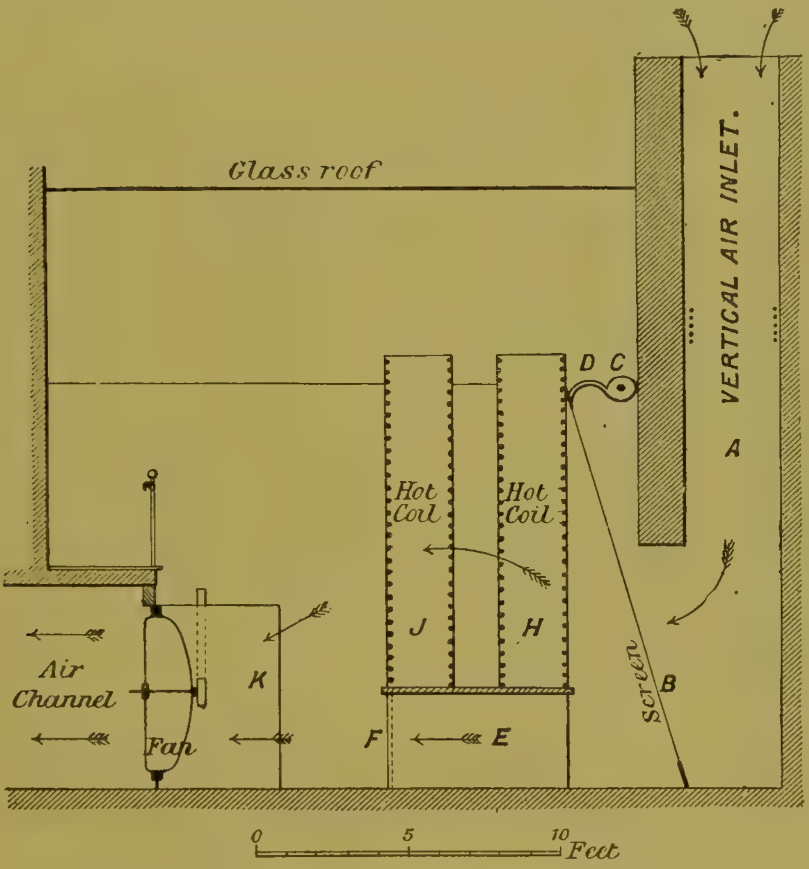
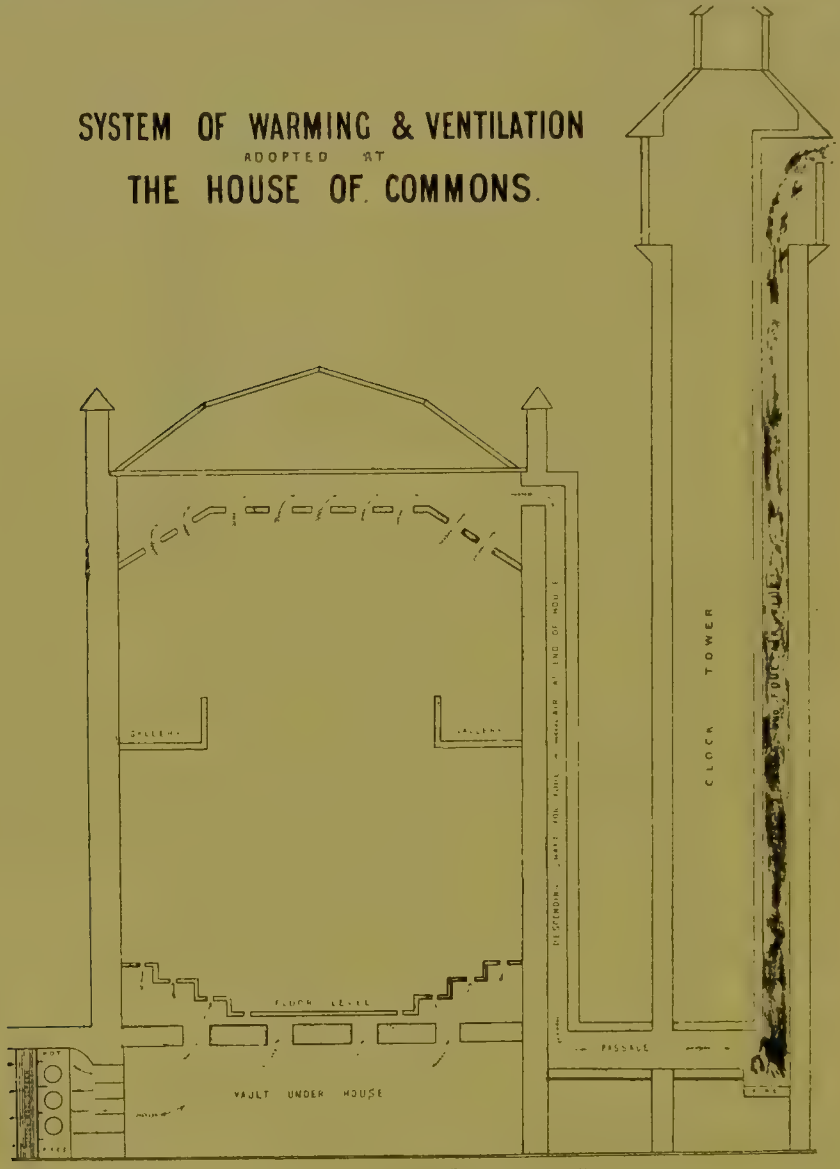


FIG. 26.—Working parts of Plenum System of Ventilation by which the air is screened, washed, warmed and propelled into the building to be ventilated.

The advantage of washing the air free of particulate matter is seen especially in foggy weather; whereas outside the building the fog may be so dense that objects a few yards off cannot be descried, inside, the atmosphere is perfectly clear. Not only so, but bacteriological examination of the air of buildings so treated abundantly shows that micro-organisms also are arrested in the process of air-washing, judging by the great difference in numbers of those in the inside and outside air respectively.[1] In some modern buildings of somewhat complex design, a combination of the plenum and vacuum systems has been introduced, the plenum fan driving the fresh air into, and a vacuum fan pulling the fouled air out of, the various rooms by means of a common duct.



1500000 CUBIC FEET OF AIR EXTRACTED PER HOUR

FIG. 27.

In the Extraction or Vacuum system, the extracting power is either a furnace connected with a tall flue, steam jets, steam- or hot-water coils placed in the extraction-flue, or a fan operated by a gas-engine, or by electricity. In the House of Commons, ventilation is accomplished by the first mode, aided by propulsion. The incoming air is forced by fans along ducts to the basement, where it is warmed when necessary by being passed over steam-coils, the heat being regulated by covering and uncovering certain of the coils with woollen cloths. The warmed air then passes up shafts into the space below the floor of the House, and after being fouled, passes through the perforated glass ceiling, and thence by ducts to the basement of the clock-tower, where by the action of a furnace it is driven up the shaft or flue. (Fig. 27.)

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[1] *Jour. San. Instit.*, vol. xix., p. 643; *ibid.*, vol. xxi., p. 273; *ibid.*, vol. xxii., p. 24.

Glover Lyon[1] has suggested and advised a method of ventilation devised by Cadett and himself in which the principles of both plenum and vacuum systems are utilised, by which he affirms that the air in rooms is maintained at nearly atmospheric pressure, the need for keeping rooms airtight is avoided, and the sensation of stuffiness of air removed.

The points to be noted in connection with any mechanical scheme, he urges are these: (1) That air entering a room in a given direction has a tendency by reason of its momentum to pass in the same direction—that is, the impulse of inlet; (2) that air flowing in a room seeks the channels of least resistance—that is, toward free apertures or outlets — the impulse of outlet; (3) that air introduced into an occupied room is heavier than the existent air, and hence tends to fall—the internal fall; (4) that vitiated, warmed air tends to diffuse itself equally in an occupied room—internal diffusion; and (5) that vitiated, warmed air tends to rise—internal ascent. Mechanical ventilation must depend upon the first two factors therefore—viz. impulse of inlet, and impulse of outlet; and the more active these impulses, the less opportunity is there for the other factors to operate. Lyon characterises Key's system and that of Sturtevant, which are plenum schemes, as schemes merely for the dilution of foul air, and the extraction system as a failure, in that it causes, in order to be effective, intolerable draughts. His scheme he declares to be a compromise between these, and is intended to effect the convection of fresh air as directly as possible to the occupants of a room and the extraction of the vitiated air from the highest parts of the room which, he avers, are the foulest. In order to ensure the efficiency of the scheme, large inlets and outlets are required, the latter of which should be well distributed over the room wall, so as to prevent "short-circuits" of air from inlet to outlet. In the scheme, the fresh air is admitted into the room by a conduit which is placed just above or below the floor near the wall. A tapering longitudinal slot is made along the top of this conduit, and baffle-plates are placed across the slot. It is contended that when air

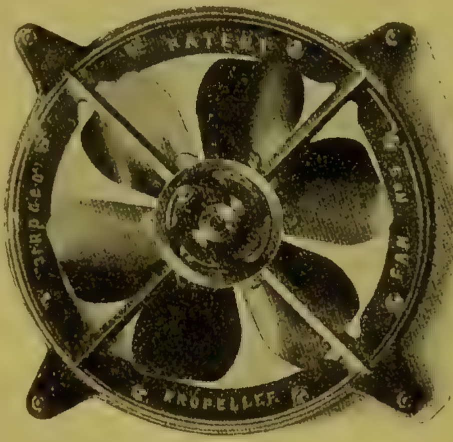

Fig. 28.—Davidson's Scirocco Patent Fan. It is claimed that owing to the propeller-like shape of its blades a larger amount of air per equal number of revolutions is propelled than by fans of different shape.

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[1] *Jour. San. Instit.*, vol. xix., p. 564; *ibid.*, vol. xx., part iv.

under velocity is forced into the end of the conduit where the slot is widest, when it reaches the narrowest part of the slot, it will be converted into an even stream of air which will flow up the wall, since its momentum is changed into pressure, by reason of the baffle-plates and the narrowed slot. If, then, a screen of wire gauze is placed above the slot and made to reach from floor to ceiling, the sheet of air flowing between the wall and the screen will be subdivided into a volume of air issuing evenly from the screen. The incoming air may be screened, washed and warmed as in the plenum method if necessary. At the outlets, a similar conduit is used, but the arrangement of the slot is reversed—that is, the widest part of the slot is at the room end of the conduit. This system, which has not yet been applied to the ventilation of occupied rooms, is to be worked in such by means of perforated panels set in the room walls as outlets and inlets, and at a level corresponding to about the middle three-quarters of the wall, having a dado below them and a frieze above. This may be one of the many schemes, more or less elaborate, which are established on sufficiently well-founded bases to give theoretically excellent results, but which are either impracticable or break down when practically applied.

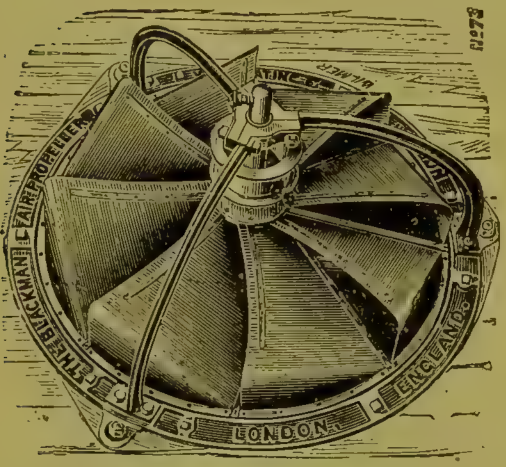

Fig. 29.—The Blackman Fan.

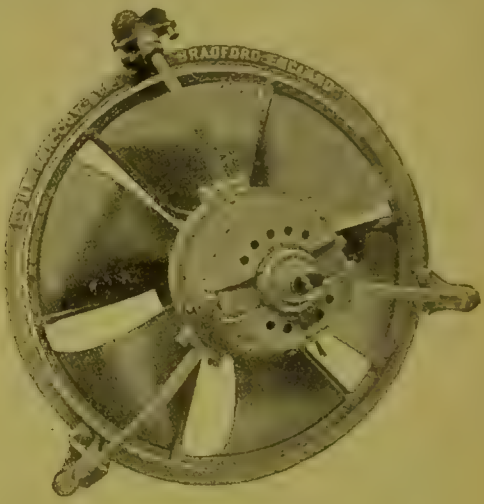

Fig. 30.—The Sun Fan.

The new operating theatre of the Central London Throat and Ear Hospital is ventilated by the Glover-Lyon system. The air is taken from above the roof of the theatre at a point most likely to be free from dust and smoke, and is passed through a perforated zinc screen which arrests small particulate matter. The air is thrown down by a noiseless propeller fan upon a series of electric heat lamps which are controlled by switches. After being so heated, the air is thrown along the wall at a point below the ceiling-level behind two screens through which evenly and at slow velocity it passes into the room atmosphere. It then passes across the room in a horizontal direction towards an outlet in the ceiling at the opposite side of the room, which outlet is provided also with a fan which draws the fouled air out of the room and propels it into the open air. The capacity of the supply fan is a little greater than that of the exhaust fan, so that when the system is in operation the room air is in a state of slight plenum, thus preventing air entering by doors or window crevices. The theatre is heated by three hot-water radiators.

The ventilation of mines is accomplished by extraction. In mines over a certain size there must be two shafts. Between these are the workings, which are so partitioned that the fresh air from the one shaft must pass through them before the air, fouled in its course, passes out by the other. In the outlet or upcast shaft the motive power is either a fire or a fan, most commonly the latter.

This extraction principle, besides, has been found of the greatest service as applied to the working benches of certain occupations in which the workers are exposed to danger to health or life, either from the nature of the material worked with, or from particulate matter of a microbic character, as the anthrax bacillus in wool- and hair-sorting. By means of openings connected with a powerful extracting current, dust and particulate matter are drawn away from the workmen into the extract shaft. In such operations as these, air-propellers, blowers, and fans perform most useful service. They can be used with much advantage, moreover, as extractors of foul air from large rooms or buildings, and when they can be had to act almost noiselessly, perform excellent service. Small fans may be actuated by water-power or electricity, larger ones, by a gas-engine or by electricity. (Figs. 29 and 30.)

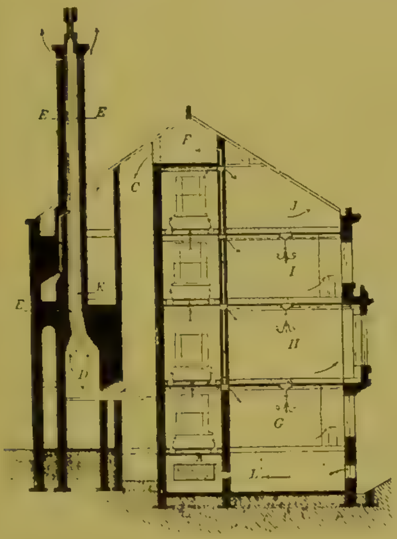

FIG. 31.—Drysdale and Hayward's combined system of Heating and Ventilation. The incoming fresh air is warmed in the basement, and is passed through the inlet-channels. By outlet-openings the foul air passes from the rooms, etc., and these converge in the chamber *F* in the roof, whence the foul air is extracted by the extracting force of the heat of the kitchen fire by means of an air-shaft which encircles the smoke-flue.

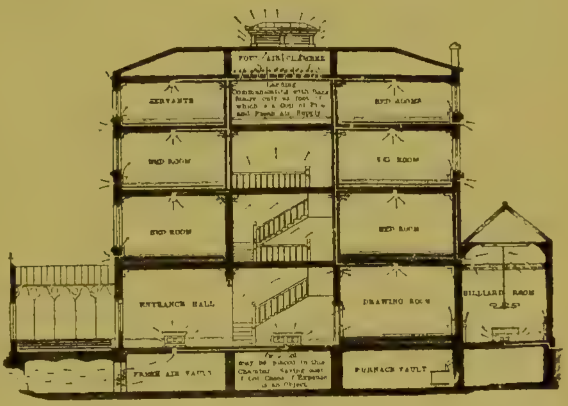

FIG. 32.—Renton Gibb's method of Heating and Ventilation. The central hall and stairway forms a reservoir of fresh, warmed air from which the rooms on the different landings are supplied. By means of extraction-shafts from each room, the foul air is conveyed to a foul-air chamber in the roof, whence by means of a ventilating turret it is passed into the open air.

Air-supply and Ventilation for Animals in Confined Spaces.—The Dairies, Cowsheds, and Milk-Shops Order of 1885 deals with the ventilation of cowsheds as follows :—Article 7. (1) "Construction of New Dairies and Cowsheds. It shall not be lawful for any person following the trade of cowkeeper or dairyman to begin to occupy as a dairy or cowshed any building not so occupied at the commencement of this Order, unless and until he first makes provision, to the reasonable satisfaction of the Local Authority, for the lighting and the ventilation including air-space, and the cleansing, drainage, and water-supply of the same, while occupied as a dairy or cowshed." (2) Such person shall give one month's notice in writing to the Local Authority before occupying any such building. Article 13 gives power to the Local Authority to make regulations respecting the foregoing.

The Scottish Local Government Board issued in 1899 a Circular respecting tuberculosis founded on The Dairies, Cowsheds, and Milk-shops Order of 1899. The word "disease" in the previous Orders of 1885 and 1887 was held to have the meaning given to it in Section 5 of the Contagious Diseases (Animals) Act, 1878. But the Order of 1899 extended its definition to include tubercular disease in cattle, and to exclude or prevent the milk from a tubercular animal being sold or used for human food. Article 13 of Order of 1899 gives the Local Authority power to inspect milch cows in dairies. In this circular, the Board invite the attention of Local Authorities in framing regulations under Article 13 of the Order of 1885 to the recommendations of the Royal Commission on Tuberculosis of 1895, respecting, *inter alia*, floor-space and cubic space for cattle in a dairy—viz.

> "A minimum floor-space of 50 feet to each adult beast.
>
> "A minimum cubic space of from 600 to 800 cubic feet for each adult beast, varying according to the average weight of the animals";

and recommended that the minimum floor-space should not be less than 50 feet in *all cases*. They also pointed out that the distribution of cubic space between area and height regulates the lateral isolation of cow from cow, not to mention the convenience of handling the animals, that cubic space added above the animals is of no advantage in this respect, and that in all prescriptions of cubic space, it is assumed that the lighting and ventilation are perfect.

When a Local Authority shall have framed regulations regarding these matters, existing cowsheds must be made to conform to the regulations prescribed within twelve months of the regulations coming into force.

Various estimates of the amount of fresh air required for animals per hour have been made by different observers. Märcker has suggested for large animals, as oxen, cows, etc., 30 to 40 cubic metres per hour for each 1000 lbs. of weight of animal—that is, one to one and a half cubic feet per pound weight of animal. For small animals, as sheep, pigs, calves, etc., 40 to 50 cubic metres per 1000 lbs. weight, or 1·5 to 1·75 cubic feet per pound weight.

Such allowances are far too low. It would almost seem as if they had been based upon some fear of lowering the temperature of a cowshed, which, in the case of milk-giving animals, undoubtedly diminishes the yield of milk.

Comparing the above figures with those for man, they will be found to be exceedingly low; the average man, weighing from 140 to 170 lbs., is expected to receive 3000 cubic feet per hour, which is equivalent to 21·5 and 18 cubic feet per hour per pound of body-weight. Applying the same rule to animals, a cow should receive between 10,000 and 20,000 cubic feet per hour. Indeed, the ideal condition is to place the animal as nearly in the same circumstances as it would be in the open air, if that were possible. Although it is true that the cow was intended by nature to be an open-air animal, the same circumstances cannot be realised in a confined space, for animals, like man, are susceptible to draughts.

Dammann would allow for an animal, such as a cow or a horse, weighing 1000 lbs. about 1800 cubic feet or 50·9 cubic metres (1800 × ·0283), and for small animals, for the same weight, 2100 cubic feet or 60 cubic metres per hour.

Reiset has summarised his observations regarding the relation of body-weight of animals to oxygen consumed, and carbon dioxide and other gases exhaled, in the form of a table, which we adduce.

TABLE XXX

Animal	Weight in Kilos	Oxygen consumed in Grammes *per Hour*	Oxygen consumed per Kilo of Body-weight	CO_2 exhaled, in Grammes *per Hour*	Nitrogen exhaled, in Grammes *per Hour*	Marsh-Gas (CH_4) exhaled in Litres *per Hour*
Sheep	67·7	33·51	0·495	42·63	0·246	1·4
Calves	97·3	45·87	0·480	54·54	0·280	1·3
Pigs	105·6	49·30	0·477	60·50	0·025	0·1
Oxen	230·0	110·50	0·480	128·80	0·293	3·07
Horses	250·0	117·42	0·470	131·62	0·295	3·66

An average sheep spoils 112 litres or 3·9 cubic feet of air per hour; an average calf, 154 litres or 5·4 cubic feet; an average pig, 166 litres, or about 6 cubic feet; an average dog of medium size, 23·5 litres or 0·83 cubic foot, and an average cat of 10 lbs., 17·8 litres or 0·6 cubic foot.

A factor in the case of several of the above-mentioned animals kept in confined spaces which tends to further pollution of the air, is that they are associated with more or less unclean surroundings, owing to their droppings.

In considering the cubic space to be given to animals, such as cows, it is to be borne in mind that greater freedom in movement of air within their quarters may be permitted, compared with the quarters inhabited by human beings; in other words, the ventilation may be much freer.

An attempt has been made to formulate a working rule for superficial and cubic spaces, relative to the bulk or mass of the animal, which shall be sufficient—viz. that 2 cubic feet of space be given per pound avoirdupois weight of the animal, the superficial or floor space being not less than one-twelfth the total cubic space thus found.

In the stables of the British army, the superficial area per horse for stall alone is 52 square feet, or for stall and proportion of passage, 90 square feet; and the army horse infirmaries, 137 square feet of floor-space for stall, or 200 square feet for stall and share of passage, per animal. In loose boxes, the floor-space is 204 square feet and the cubic space, 1900 cubic feet.

Ventilation of Byres and Cowsheds.—An inlet area of 30 to 40 square inches, at least, should be provided per animal, and an outlet area of from 40 to 50 square inches. The inlet-openings ought to be provided in the walls, and the outlet-openings in the roof. The former may consist of perforated gratings or ungrated openings at a level of five to six feet from the floor, and the latter of louvred openings placed on the roof-ridge. In the case of the inlets it is better, when possible, to have these on opposing walls. The doors should be thrown freely open whenever possible. Lighting should be efficient. In modern byres the rule is to allow 3 square feet of glass for each animal, the windows being placed either in walls or roof, and if in the roof, preferably on the north or east side.

Ventilation in the Tropics.—It has been alleged with some force that not a little of the ill-health of Europeans resident in tropical countries is due to defective ventilation of their dwellings, and that the methods of ventilation suitable for temperate climates are quite inapplicable and unfitted for tropical climates. The problem has been put thus: A person proceeding to Bombay, for example, from this country is during the hot season suddenly plunged into circumstances he has never before experienced. The mean temperature of Bombay (79·13° F.) is 30° higher than that of Great Britain, and the mean amount of humidity of the atmosphere 1·135 lbs. per 1000 cubic feet of air, compared with, say, 0·51 lb. in London. Under average conditions of health the human body must get rid of 284 units of surplus heat in order that the normal temperature, within half a degree, may be maintained. This is made more difficult in tropical countries, and especially so in humid climates, by reason of the high atmospheric temperature, which, in the hot season, is likely to be seldom less than 98° in the shade. Hence it follows, in order to get rid of the surplus heat, that there must be greater movement of air in tropical climates in any scheme of ventilation than in a temperate climate; or, to put it in another way, in a tropical climate the average Briton bears with comfort a velocity of air which could not be borne with impunity in this country. Natural ventilation, therefore, is of little count in the tropics. Movement of air must be obtained by some form of mechanical propulsion; hence the time-honoured punkah. But the mere mechanical movement of air within an apartment is not sufficient unless there be free outlets for the air which is moved. Electrically worked fans, with effective outlets, both in size and in position, coupled with moistened screens at inlets, would largely help to solve the problem. The following experiment, made in a bungalow at Cawnpore, shows what may be achieved by natural forces:—In the building in question there was no ventilation opening above the windows. A square hole, 22 inches square, was cut in the roof of the largest room, and fitted into it was a thin sheet-metal unpainted square chimney, 10 feet in height. Its total superficies was 73 square feet, one-half of which received the sun's rays directly. By the heat absorbed therefrom, an induced current was set up in the chimney, and, therefore, through the room. The following observations were made at 2.30 P.M., the hottest part of the day—viz. Temperature of air of room, 97° F.; temperature of air issuing from chimney-shaft, 113° F.; increase of temperature in shaft, 16° F.; velocity of air-current, 133·2 linear feet per minute; volume of air discharged by flue per hour, 26,553 cubic feet.

The effect of the flue was to make the room fresh, pleasant and comfortable.[1] Another experiment was made in an office room in the same building. Each morning 7·5 gallons of water were poured on the floor and absorbed. In the course of the day the water was gradually evaporated. Doors were kept as much open as possible and punkahs in constant use. The office was thus made comfortable. The following observations respecting the humidity of the air were made :—

	Dry-Bulb Thermometer	Wet-Bulb Thermometer	Relative Humidity of Air
On Verandah . .	103° F.	89° F.	56 per cent.
In Office . . .	88° F.	85° F.	87 ,,
Difference . .	15° F.	4° F.	31 ,,

The point chiefly to be aimed at in ventilation in tropical countries is to secure adequate movement of air, fresh air being supplied and fouled air escaping. The method already described is simple and has proved effective; but, as has been said, electrically propelled fans, with sufficient outlets in size and position, with the addition of moistened screens at inlets, would go far to solve the problem.

Mode of Testing practically Schemes of Ventilation.—There are three special branches into which an investigation into the efficiency of any large scheme of ventilation divides itself—viz.

I. The cubic space to be filled with fresh air, and the number of times per hour the air of the said space must be changed with reference to the number of occupants at any given time.

II. The efficiency of the mechanism by which the air-movement is to be effected.

III. Tests of the efficiency by physical and chemical methods.

1. The Cubic Space of the Building or Room to be ventilated.

In ascertaining the cubic contents of any confined empty space of the simplest kind, the multiplication of its length, breadth, and height in feet will give its amount in cubic feet. But in irregularly-shaped rooms, special measurements must be made—that is to say, the cubic space may be estimated by a series of measurements for irregular spaces—the sum of which is the total cubic contents of the space. The following data will adapt themselves to any shape of room :—

Superficial Spaces

Area of Circle = $D^2 \times 0{\cdot}7854$.
Circumference of Circle = $D \times 3{\cdot}1416$.
Area of Ellipse = Product of both diameters × 0·7854.
Circumference of Ellipse = Half the sum of both diameters × 3·1416.
Area of Segment of Circle = $(\text{Chord} \times \text{Height} \times \frac{2}{3}) + \frac{\text{Height}^3}{2\text{ Ch.}}$
Area of a Square = The square of one of the sides.
Area of Rectangle = The product of two of the adjacent sides.
Area of Triangle = Base × Half the height.
Area of a Parallelogram = Bisect into two triangles by a diagonal, and estimate the sum of the areas of the two triangles.

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[1] *Lancet*, vol. ii., 1909, p. 492.

Cubic Space
Cubic Capacity of Cube = length × breadth × height.
,, ,, Solid Triangle = area × $\frac{1}{3}$ height.
,, ,, Cylinder = area of circular base × height.
,, ,, Cone = area of circular base × $\frac{1}{3}$ height.
,, ,, Dome = area of circular base × $\frac{2}{3}$ height.
,, ,, Sphere = diameter^3 × 0·5236.

In one or other or more than one of these ways, the *gross* cubic contents of any space may be estimated. After deduction of the cubic contents of solid or closed bodies, as furniture, etc., the *net* cubic contents are arrived at. For a bed it is customary to allow ten, and for an adult three cubic feet.

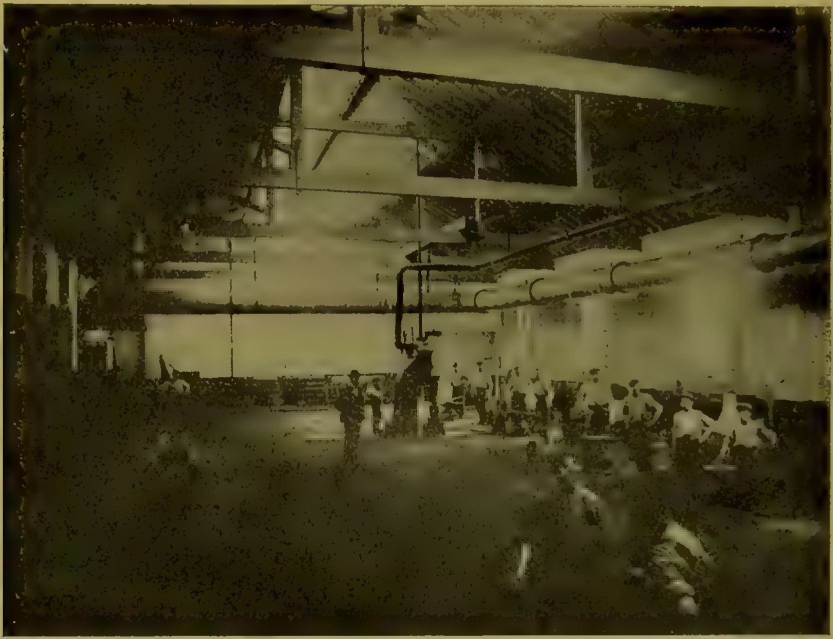

FIG. 33.—Illustrates the Ventilation and Purification of Air of a Smith's Shop by means of the "Scirocco" Fan. The position of the fan is indicated on the left of the figure, at the end of the exhaust air-shaft which is seen to pass from the right to the left of the figure, and into which passes the smoke which, otherwise, would pollute the atmosphere of the workshop.

2. The next step is to ascertain the number of occupants—the average, minimum, and maximum numbers—in the case of a hall, church, or school. For a mixed adult audience, an allowance of 3000 cubic feet of air per hour is the ideal to be aimed at; for children of mixed ages in schools, 2000–2500 cubic feet per hour. These allowances per head per hour multiplied by the number of occupants gives the total number of cubic feet of air to be supplied per hour.

Examine next for inlets and outlets. The superficial area of inlets and outlets, where the air is warmed, should not be less than 48 square inches per person. This will allow of the air being sent in at a velocity of about 2½ feet per second. But these may be enlarged up to 70 or 80 square inches per head—the air being warmed—where the net cubic space for the total number of individuals is less than the ideal amount. The sum of the superficial areas of inlets or outlets divided by the number of occupants will give the inlet or outlet area per individual.

The rate of velocity of the incoming air at the inlets must then be tested by the anemometer. The instrument should be placed, not in the centre of the opening, but at a point about $\frac{2}{5}$ths of the diameter from its side, as this point best gives the mean velocity. The instrument having been maintained for one minute in this position, the number of revolutions registered, minus the correction for the individual instrument—supplied by the makers—will give the linear velocity in that time; and the linear velocity multiplied into the sectional area of the opening will give the number of cubic feet supplied per minute. It is a good plan to apply the anemometric test to a series of inlets in various parts of the room. This test, in our opinion, is the most important of all from the practical point of view, as it demonstrates the *actual* amount of air which is being supplied to the room. The temperature of the incoming air, of the room itself at various points, and at various outlets, ought also to be taken. The supply of air will be found to be most constant in the *plenum* system, since the motive power may be kept constantly doing a definite amount of work. By comparison, therefore, of the figures of the *actual* supply of air as estimated, with the amount required or desiderated, the efficiency of the ventilation-machinery may be tested. In testing under the vacuum method, the same general principles as the foregoing apply. It has been already stated that the rate of movement

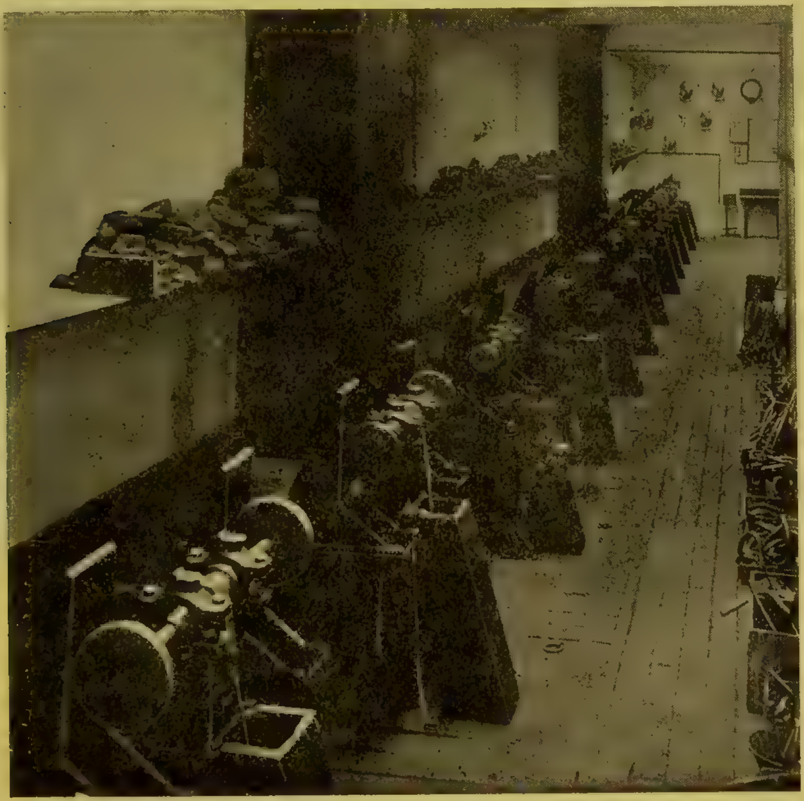

FIG. 34.—Workshop, the air of which is kept free of the particles from the grinding machines by means of the exhaust shafts seen immediately beneath each wheel.

of air depends upon the difference in temperature between the outside air and that of the extracting shaft, chimney or flue. Where the motive power is a fan working in or at the bottom of the shaft, the rate will depend upon the sectional area of the fan and its velocity or number of revolutions per minute.

It may be necessary, sometimes, to calculate the amount of air which is being, or may be, delivered by fans. To do this a knowledge of the following factors is required—viz.

1. Diameter of fan in feet or terms of a foot ;
2. Number of revolutions of fan, or velocity, per second or per minute ;
3. Tangential velocity of the air leaving the fan. This may be taken in the average case as three-fourths the velocity of the tips of the blades or vanes of the fan ;
4. Diameter of outlet from fan.

An example will, perhaps, best illustrate the method of calculation : A circular fan has a diameter of 5 feet, turns at 6 revolutions per second, and has an outlet of 2 feet. Find the amount of air delivered in cubic feet per hour.

Circumference of the circle described by one revolution is
$3{\cdot}1416 \times 5$ ft. $= 15{\cdot}708$.

Velocity of each blade or vane $= 15{\cdot}708 \times 6$ (No. of Revolutions) $= 94{\cdot}248$ feet per second.

Velocity of air-current leaving fan $= 94{\cdot}248 \times {\cdot}75 = 70{\cdot}686$ feet per second.

Area of outlet $= \pi \times (r)^2 = 3{\cdot}1416 \times 1 = 3{\cdot}1416$ square feet.

$\therefore$ Discharge per second $= 70{\cdot}686 \times 3{\cdot}1416 = 222{\cdot}06$ cubic feet.

Discharge per hour $= 222{\cdot}06 \times 60 \times 60 = 799{,}416$ cubic feet.

It is also advisable to know how to calculate the proper size and speed of a fan which would be required to deliver a certain required number of cubic feet per hour.

Let the problem above be taken as an example, thus :

The amount of air required to be supplied to a hall per hour is 799,000 cubic feet. It is required to calculate the size and speed of a fan to perform this work ; in other words, to find the diameter and the number of revolutions of the fan ; the diameter of the inlet being 2 feet.

Delivery = velocity of air-current × area of inlet.

Radius of inlet = 1 foot.

Area $= \pi \times 1 = 3{\cdot}1416$.

$\therefore$ $799{,}000 =$ velocity of air-current $\times\ 3{\cdot}1416$.

$$\therefore\ \frac{799{,}000}{3{\cdot}1416 \times 60 \times 60} = \overset{\text{feet}}{70{\cdot}64} = \text{velocity of air-current per second.}$$

But taking the tangential velocity into account, this becomes

$$\frac{799{,}000 \times 4}{3{\cdot}1416 \times 60 \times 60 \times 3} = \overset{\text{feet}}{94{\cdot}2} = \text{velocity of vanes, or distance traversed per sec.}$$

$$\text{Or, } \frac{799{\cdot}000}{3{\cdot}1416 \times 60 \times 60 \times {\cdot}75}$$

Let D = Diameter of fan required, and R = Number of Revolutions required.

$3{\cdot}1416 \times D$ = Circumference of fan in feet.

$3{\cdot}1416 \times D \times R$ = Distance traversed by a fan-blade in one second.

$\therefore\ 3{\cdot}1416 \times D \times R$ = 94·2 feet, as found.

$$\therefore\ D \times R = \frac{94{\cdot}2}{3{\cdot}1416} = 29{\cdot}985 \text{ or } 30{\cdot}0 \text{ feet.}$$

$$\therefore\ D = \frac{30}{R}\ ;\quad R = \frac{30}{D}.$$

If the number of revolutions is 10 per second, D = 3 feet.
If the number of revolutions is 5 per second, D = 6 feet.

If the diameter of the fan is 6 feet, and the number of revolutions per second be 5, then such a fan would deliver 799,000 cubic feet per hour.

In a heated chimney flue or shaft, whether the source of heat be a furnace, coils of steam piping, or a steam nozzle, the rate of movement depends upon the action of two well-known physical laws—viz.

1. That the velocity of a falling body in feet per second is equal (nearly) to 8 times—in fact, 8·02 times—the square root of the distance or height through which it has fallen.

$$V = \sqrt{2gH}$$

where v = velocity;
g = gravity = 32·18, the number of feet fallen in one second;
H = height or distance.

$$\therefore \sqrt{2g} = \sqrt{64{\cdot}36} = 8{\cdot}02 \text{ nearly, or } \underline{8}.$$

2. That fluids flow through an aperture with a velocity equal to that of a body falling through a height equal to the difference in height of the columns of air on either side.

The formula now becomes : $\underline{V} = 8\ \underline{\sqrt{H - h}}.$

In applying these laws, which are known as *Montgolfier's Theorem or Rule*, to the movement of air, account must be taken of the different densities of air at different temperatures due to its expansion by heat. H is taken to equal the height of the atmosphere, which may be considered to be a column of air of uniform density and five miles in height, and which, at sea-level, supports a column of mercury of 760 millimetres in height. If, then, such a column of air were to rush into a vacuum, it would do so with a velocity equal to that of a solid body falling through a distance of five miles, or 26,400 feet—viz. of about 1300 feet per second :

$$\sqrt{2gH} = \sqrt{2 \times 32{\cdot}18 \times 26{,}400} = \underline{1303} \text{ feet per second.}$$

But if the same column of air were to pass into a room the air of which is not a vacumn but which has less pressure than itself, then its velocity will be equal only to that attained by a solid body falling through a height measured by the difference of the pressure inside and outside, as estimated from the difference of the temperatures. Where heating takes place in a flue or chimney open only at both ends, the expansion of the air can only take place by the confined column of air becoming longer. This increase of length corresponds to h. We have seen that one volume of air expands $\frac{1}{491}$ part for each degree Fahrenheit it is raised in temperature above 32°. The coefficient for this amount of expansion is ·002036, or, shortly, ·002. The difference in pressure, therefore, is ascertained by multiplying the difference in temperature of the outside and inside air by this coefficient of expansion—viz. ·002.

From these data, then, the following formula is constructed :—

$$V = \sqrt{2gHa(t - t')}.$$

Where V = velocity of ascending air in feet per second ;
H = height of shaft or flue in feet ;
t = temperature of air in shaft ;
t' = temperature of outside air ;
a = coefficient of expansion of air = ·002 per degree F. ;
g = 32·18 = number of feet fallen by a body in first second.

Example.—A ventilating-shaft, fifty feet in height, straight and circular in shape, has a sectional area of three feet ; the temperature in the shaft is 65° F., that of the outside air being 45° F.; it is required to find the quantity of air passing out per hour.

$$V = \sqrt{2gHa(t - t')}$$
$$V = \sqrt{2 \times 32{\cdot}18 \times 50 \times (65 - 45){\cdot}002}$$
$$V = 113 \text{ feet per second of linear velocity.}$$

The linear velocity multiplied by the sectional area of the shaft will give the amount of air in cubic feet discharged per second. The sectional area in this case is 3 feet.

Therefore $113 \times 3 \times 60 \times 60 = 1{,}220{,}400$ cubic feet per hour.

It must be noted, however, that the *calculated* or *theoretical* linear velocity is not realised in experience, because of friction in the shaft; hence the *actual* velocity is diminished according to the amount of friction which the outgoing air experiences, and this depends upon the character of the shaft, in respect whether it be circular or square, straight or curved, or angular, and whether its interior be smooth or rough. Allowance must, therefore, be made in practice for friction, which allowance may vary from $\frac{1}{4}$ to $\frac{1}{2}$ the linear velocity. This, however, may be checked by anemometric observations.

The formula for ascertaining the movement or velocity of heated air in a vertical flue may be extended thus:

$$V = E\sqrt{2g\frac{h.\ a.\ (t' - t)}{1 + a.\ t.}} : \text{ where}$$

V = velocity of ascent of air-current per second;
E = a numerical coefficient, constant for each flue, and expresses the reduction of theoretical velocity due to friction, eddies, etc.;
g = gravity;
h = height of flue in feet;
a = coefficient of expansion of air = ·00204 for 1° F.;
t' = temperature of heated air in flue;
t = ,, of outside air.

This is merely an extension of Torricelli's theorem: the velocity of a freely falling body is equal to the square root of twice the gravity, where $g = 32{\cdot}2$ lineal feet per second, h = height through which the body falls:

$$V = \sqrt{2gh}$$

When air is heated at constant pressure it increases in volume; and where the heated air is confined in a vertical flue open at both ends, it is evident that the expansion of volume must cause an extension in length of the confined column, and so it must escape at the top of the flue. Such difference in height of column of air, due to increase of temperature, is expressed in the foregoing formula by h. The difference between the original length of the column at temperature t, and the extension of length due to increase of temperature t', is equal to the height through which a volume of air at outside temperature t—that is, the original volume of air within the flue—has fallen, to cause the upward movement within the flue; therefore h is the head of fluid—air, in this case—causing the pressure.

The conditions of discharge of air in a vertical flue depend upon the following factors:—

1. The height of the flue. The power of the flue, or the velocity of its discharge of air, increases as the square root of the height increases, the difference of temperature of air between inside and outside of flue remaining constant;
2. The square root of the difference of t'—*i.e.* inside temperature—and t outside temperature; in other words, in a flue of constant height the velocity of discharge will increase as the difference between inside and outside temperature increases;

3. Resistance. The greater the friction or resistance in a flue from bends or elbows, or other source of friction, the less the velocity of discharge. Straightness, adaptation of cross-section, and smoothness of interior of flue are, therefore, all contributory toward increase of velocity of discharge in the direction of theoretical maximum.

Based on these laws, du Chaumont has proposed two formulæ:

(1) For calculating the total size of outlets and inlets required to deliver a given number of cubic feet of air per hour—

$$\frac{D}{100\sqrt{H(t-t'\times\cdot002}} = \phi$$

(2) To determine the delivery per hour, the size of the inlet-opening or openings being known—

$$200\sqrt{H(t-t')\times\cdot002}\,\phi = D$$

Where D = delivery of air in cubic feet per hour;
H = height of shaft in feet;
t = temperature inside shaft;
t' = temperature of outside air;
ϕ = sectional area of inlet, or outlet, in square inches;
200 = a constant, obtained by dividing the number of seconds in one hour by the number of square inches in a square foot, and multiplying the product by the square root of twice the gravity;

$$\text{thus: } \frac{3600}{144} = 25\times(\sqrt{32\cdot2\times2}) = 8 = 200.$$

3. The third branch of the inquiry consists in the application of physical and chemical tests to the air of the place. The best physical tests to employ for rooms occupied for an hour or two consecutively—as for example, a schoolroom—is the estimation of watery vapour, and temperature. In imperfectly ventilated rooms there is a definite increase of watery vapour, and the temperature is also raised some degrees. Such an atmosphere becomes oppressive, and, without any examination as to efficiency of action, the particular system of ventilation in use is liable to be blamed as the cause. The element in the atmosphere of a room which lends itself most easily to chemical analysis is the Carbonic Acid gas, and this may be taken as a comparatively accurate measurement of the amount of organic matter in the same air. The researches of Carnelly and others[1] demonstrate this. To estimate the amount of CO_2 present in air, different methods may be employed, as those of Angus Smith, Lunge-Zeckendorff, Wolpert, Hesse, and Pettenkofer, the first three of which, however, are only approximate methods.

Approximate Methods.—1. The method of Angus Smith requires a series of stoppered bottles, measuring respectively 20½, 10½, 8, and 6½ ounces. The reagent used is lime-water or baryta-water, and the amount used at each experiment is half an ounce. The test is employed as follows:—Into the 10½ ounce bottle is put the necessary amount of lime-water, and the bottle stoppered and shaken freely for about one minute. Should the clear reagent have now become turbid, the sample of air contains more than ·06 per cent. of CO_2; if no turbidity result, it does not contain more than this proportion. By using the other-sized bottles, the quantity greater than ·06 per cent. may be approximately arrived at by observing in what size of bottle, with the like quantity of reagent, turbidity appears.

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[1] *Roy. Soc. Trans.*, vol. 178, 1888.

Size of Bottle in Ounces	No Precipitate CO_2 per cent.
20½	·03
10½	·06
8	·08
6½	·10

It will be obvious from the health point of view, that little concern will attach to percentages of CO_2 less than ·06.

2. *The Lunge-Zeckendorff Method* requires care on the part of the operator so that the necessary conditions for accuracy may be fulfilled; otherwise, the method is simple. The apparatus consists (1) of a bottle of known cubic capacity, stoppered by an indiarubber cork perforated in two holes through which pass two glass tubes, one of which is connected with (2) a rubber ball of definite capacity, by means of rubber tubing. The reagent used is a $\frac{N}{500}$ or 500th normal standard solution of carbonate of soda (·02 gramme per litre), coloured pink with phenolphthalein as an indicator. It is better to make a $\frac{N}{10}$ solution—viz. 5·3 grammes dry Na_2CO_3 per one litre of water after addition of 1 gramme of indicator dissolved in alcohol. For use, 2 c.c. of this solution are diluted to 100 c.c. with distilled water, of which 10 c.c. are used for each determination. To use the apparatus 10 c.c. of the $\frac{N}{500}$ solution are put into the bottle with a pipette, the attachments are fixed, and the rubber ball is compressed and released alternately so as slowly to force the air through the solution in the bottle, the contents being agitated after each ballful, until the pink colour disappears. The disappearance of the colour shows that the alkaline carbonate has been converted into the acid carbonate by the CO_2 added from the air, as the indicator-colour is discharged in acid solutions. Reference to a table, which is supplied with the apparatus, shows, from the number of ballfuls used, the percentage amount of CO_2 in the air examined. Provided that care is exercised in the filling and emptying the rubber ball, in passing the air through slowly and regularly, and in agitating the reagent, our experience of the method is that it is a fairly reliable approximate guide to the atmospheric CO_2 present.

3. *Wolpert's Method.*—The rationale of this method is exactly the same as the preceding, but the apparatus used is different. The apparatus consists of a glass cylinder marked in ½ and 1 c.c. into which is fitted a piston, the lower extremity of which is made of indiarubber to cause it to fit exactly. The piston shaft is hollow. The upper extremity is fitted with an indiarubber cap, which is removable. The shaft of the piston passes through a metal cap which is adjusted to the top of the glass cylinder. The reagent used is a standardised solution of pure dry sodium carbonate, containing phenolphthalein as an indicator, in dilute alcohol and water, 1 c.c. of which contains ·074 mgrm. of the soda and ·016 gramme of phenolphthalein. *Process.*—In order to fill the glass cylinder with air to be examined it is only necessary to work the piston up and down three or four times. To estimate the contained CO_2 remove the piston, put into the cylinder 2 c.c. of above coloured alkaline solution, replace cylinder, push it down to the 10 c.c. mark, put cap on piston, and shake cylinder and contents; if colour be not discharged, pull out piston to 20 c.c. and after replacing cap on piston, again shake. By continuing this process until the solution becomes decolorised, the amount of CO_2 present is calculated thus: From number of c.c. of air used, deduct 2 c.c. for space occupied by solution and divide 31·3 by the remaining figure. The figure 31·3 represents the number of c.c. of air containing 1 part CO_2 per 1000 of air which is necessary to decolorise 2 c.c. of the above coloured alkaline solution. In the more modern instruments

by means of a graduated scale engraved on the apparatus the parts per 1000 are supplied, and the calculation, therefore, rendered unnecessary.

Dr Andrew Hall has devised a method for the use of inspectors, the principle being to match the turbidity or milkiness produced in baryta-water, which has been shaken up in a bottle containing one litre of air, by a solution of barium carbonate of definite amount in distilled water. The instrument or apparatus is called the carbonometer and is arranged in a cabinet. The apparatus consists of: (*a*) a flask, the exact capacity of which is 1025 c.c.; (*b*) a set of ten bottles each containing 25 c.c. of baryta-water of 0·2 per cent. strength; (*c*) two bottles, each 25 c.c. capacity, for distilled water; (*d*) a bottle containing pellets of barium carbonate, each containing ·00352 gramme of that salt; (*e*) a bottle containing similar pellets, each containing, however, only ·00088 gramme of barium carbonate; (*f*) a bottle of distilled water; (*g*) bottle containing dilute solution of nitric acid (1 c.c. to 175 c.c. water); and (*g*) auxiliary vessels.

Modus operandi.—Starting from the general fact that pure air contains 4 parts CO_2 per 10,000, and from the assumption that any proportion of CO_2 beyond 6 parts is objectionable, and from the further fact that 4 parts of CO_2 per litre of air when combined with barium oxide will form ·00352 gramme of barium carbonate, a standard is formed by mixing a pellet of barium carbonate weighing ·00352 (one of the larger pellets supplied) with 25 c.c. distilled water in one of the bottles provided for that purpose. The turbidity so produced is equal to the turbidity formed by the union of 25 c.c. of baryta-water with a litre of air containing ·0004 parts of CO_2. To test the air of a room, the flask of 1025 c.c. capacity is filled with water and emptied, and drained in the room, and thereafter the contents of one of the bottles containing 25 c.c. of baryta-water are added, the flask is stoppered, and the contained air thoroughly washed of its CO_2 by forcible shaking of the contents. Thereafter, the now turbid or milky liquid is rapidly poured into one of the clean 25 c.c. bottles, and its turbidity compared with that produced in the standard bottle. If they are alike, then the air of the room contains ·0004 parts per litre or 4 parts per 10,000 of air. Should, however, the test bottle be more turbid than the standard bottle, one or more of the smaller barium carbonate pellets is added until the turbidity in both bottles is equal. Since each of the smaller pellets represents one part CO_2 per 10,000 of air, one must be added to the four parts of CO_2 for each small pellet added.

As a means of estimating approximately the purity or impurity of air in occupied rooms, the method, up to a certain point, is reasonably satisfactory, but a point in these experiments is not unfrequently reached in practice where the air is very impure, at which it is very difficult to compare or match the relative turbidities. It may be said, however, that since the object of the method is merely to pronounce whether or not the air of a room is below or above six parts CO_2 per 10,000, the test fulfils its purpose.

Exact Methods.—Pettenkofer's method is, however, one of the most exact.

It may be carried out in one of two ways, (*a*) either by the use of large glass jars, such as very large Winchester quarts, the cubic capacity of which in c.c. is known and marked thereon, or (*b*) by the use of air-tubes—Pettenkofer's latest mode—connected with an aspirating apparatus of known capacity.

The following apparatus is required:—

(1) Glass jars, fitted with indiarubber stoppers, holding about 4000 to 6000 c.c.; or two Pettenkofer tubes;
(2) Burette, graduated in c.c. and tenths, to hold 100 c.c.;
(3) Pipettes to hold 30, 50, and 60 c.c. respectively.

Chemical Solutions required:

(1) A clear solution of baryta-water made up of 4½ grammes of barium hydrate and ¼ gramme of barium chloride, per litre of distilled water; barium chloride is added because the barium hydrate usually contains small proportions of Ba_2CO_3 and NaHO or KHO. The chloride converts the NaHO into NaCl and the $BaCl_2$ into the hydrated oxide, thus:

$2NaHO + BaCl_2 = 2NaCl + Ba(OH)_2$. Without the addition of the chloride, exact titration is prevented.

(2) Standard solution of oxalic acid, made by dissolving 1·404 grammes of the pure crystals in one litre of distilled water, and of which 1 c.c. =·25 vol. of CO_2.

$$\text{Thus: Oxalic Acid} = \frac{C_2O_4H_2 + 2H_2O}{12 \times 2 + 16 \times 4 + 1 \times 2 + 2 \times 2 + 16 \times 2 = 126}$$

$$\text{Carbonic Acid} = \frac{CO_2}{12 + 16 \times 2 = 44}$$

One molecule $Ba(HO)_2$ consumes, or takes up, 1 molecule oxalic acid to form barium oxalate $(BaC_2O_4 + 4H_2O)$. One litre of CO_2 at normal temperature and pressure weighs 1·971 grains $(·0896 \times \frac{44}{2} = 1·971)$ and a quarter of a litre, $1·971 \div 4 = ·492$ gramme. Therefore the amount of oxalic acid to be used is $\frac{126 \times 0·492}{44} = 1·404$ grammes, of which 1 c.c. is equivalent to 0·25 vol. of CO_2.

(3) Saturated solution of phenolphthalein, as an indicator.

Rationale of Process.—The test depends upon the relative causticity or alkalinity of the baryta-solution before and after its exposure to the air which contains the CO_2, the amount of difference in alkalinity being the measure of the amount of CO_2 present.

Modus operandi.—The jar to be used is filled with water, and is emptied and allowed to drip dry in the place the air of which is to be examined. Thereafter, 60 c.c. of the baryta-water are poured into the jar, the rubber stopper tightly fixed, and the bottle and contents are periodically agitated during the next ½ to 1 hour. Meanwhile, 30 c.c. of the baryta-water, to which have been added two drops of the phenolphthalein solution, coloured pinkish-red thereby, are titrated in a practically closed flask with standard oxalic acid from a burette. The acid is allowed to run in regularly, with constant agitation of the flask, until the pink colour is discharged ; the number of c.c. of acid used is noted. A second more carefully performed test is then made in the same way, but special care is given to the *end-reaction.* Then the quantity of acid in c.c. used in neutralising the 30 c.c. of baryta-water is put down. At the end of the hour, the baryta-water in the air-jar is poured out by means of a glass funnel into a 100-c.c. glass-stoppered bottle, is there allowed to remain until the carbonate of barium, formed by the CO_2 of the air with the solution, sediments, after which, by means of a 30 c.c. pipette, that quantity of the supernatant clear fluid is pipetted off into a clear-glass flask, two drops of the indicator are added, and it is titrated by the standard oxalic acid. The quantity of acid needed to discharge the pink colour is again noted.

Having ascertained the alkalinity of the baryta-water both before and after exposure to the air of examination, it now remains, after noting the temperature of the air, to calculate the result.

Let us say that the cubic contents of air-jar =5060 − 60 for space occupied by baryta-water.

Causticity or alkalinity of baryta-water—

Before exposure, required of oxalic acid =39·5 c.c.
After exposure, ,, ,, ,, =33·5 c.c.

∴ 39·5 − 33·5 = 6 c.c. = Half amount of baryta-water changed into carbonate by amount of CO_2 in air in jar.

But 1 c.c. of standard oxalic acid equals 0·25 vol. of CO_2 ;

∴ 0·25 × 6 = 1·5 vols. of CO_2 in *half* the amount of baryta-water taken ;

∴ 1·5 × 2 = 3 vols. of CO_2 in total air-contents of jar.

The calculation, therefore, works out thus :

$$5060-60 : 10{,}000 : : 3 : x. \quad x = \cdot 6 \text{ vols. per 10,000 of air.}$$
$$= \cdot 06 \text{ vols. per 1000 ,,}$$
$$= \cdot 006 \text{ vols. per cent. ,,}$$

For very accurate work, temperature and pressure during the experiment must be taken for calculation at standard temperature and pressure –0° C., and 760 m.m.

$Vo =$ vol. at 0° C.,
$Vt =$ vol. at t° C.,
$a = \cdot 00366 =$ coefficient of expansion for 1° C.,

$$\therefore\ Vo = \frac{Vt,}{1+at}.$$

Thus, suppose in the foregoing test the temperature was 15·5° C. ; to ascertain the volume of air in jar at 0° C. :

$$Vo = \frac{Vt}{1+at} = Vo = \frac{5000}{1+\cdot 00366 \times 15{\cdot}5} = Vo = \frac{5000}{1{\cdot}05673} = Vo = 4731{\cdot}76 \text{ c.c.}$$

If it be desired to correct for both temperature and pressure, the following formula may be used :—

$$Vo_{760} = \frac{Vt \times b}{(1+at) \times 760}$$

where b = barometric pressure found during experiment ; the other terms remaining as above.

Professor Walker of Edinburgh[1] has devised a method of estimating the amount of CO_2 in air whereby is obviated the inconstancy of results not infrequently obtained by processes in the use of which the expired air of the experimenter is apt to be absorbed by the baryta-water during the process of titration. This inconstancy of results is common in processes in which titration is conducted in the open. The method is really a modification of Pettenkofer's bottle method, owing to the defects of which that observer devised later his tube method hereinafter described. Walker claims for the method a possible accuracy of result of 0·1 part CO_2 per 10,000 of air.

Apparatus used.—The bottle employed is a clean, dry Winchester quart, the exact capacity of which has been ascertained. It is furnished with a rubber stopper through which pass two glass tubes about 7 m.m. in diameter. One of the tubes reaches almost to the bottom of the bottle, the other, the shorter, ends internally flush with the stopper. Both tubes project externally beyond the stopper about two inches, and are provided with glass stopcocks at different levels, to permit of convenient manipulation. To the projecting end of the longer tube a piece of rubber-tubing, one inch in length, is permanently attached, by which the tube may be connected with the spit of the baryta-water burette.

Modus operandi.—The bottle being filled with the air to be analysed, by bellows or otherwise, the spit of the baryta-water burette is fixed to the rubber-tubing at projecting end of long tube, and, both stopcocks being now opened, 50 c.c. of baryta solution are run into the bottle. The spit of burette is then detached, and the piece of rubber-tubing pinched so as to drive the solution below the stopcock. Both stopcocks are then closed, and the bottle, now placed on its side, is agitated from time to time.

While the CO_2 of the air of flask is being absorbed, an asbestos filter is prepared. The form advocated by Walker is a Soxhlet cuprous oxide tube fitted into a filtering flask of about 200 c.c. capacity with side tubulure by means of a rubber stopper. Asbestos, teased out, is pressed down over the capillary portion of the tube, the filter-pump is set a-going, and the asbestos freely washed with distilled water run through the filter-tube.

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[1] *Trans. Chem. Soc.*, vol. 77, 1900.

Absorption of the CO_2 being completed—fifteen to twenty minutes ordinarily suffice—filtration of the now turbid baryta-solution from the bottle may now be commenced.

Ten c.c. of $\frac{N}{10}$ hydrochloric acid are run into the empty flask by means of a pipette reserved for this purpose, the filter-tube is adjusted in position, and the flask is firmly clamped at the neck. The air-bottle is now inverted, and in that position is also clamped at the neck on the same stand as the filter-flask at a height of about 8 inches above the top of the filter-tube. Into the top of the filter-tube is now fitted a rubber stopper which passes a short glass tube carrying a length of rubber tubing $\frac{1}{8}$th inch bore and $\frac{3}{8}$ths inch in diameter, the other end of this rubber being adjusted to the extremity of the shorter glass tube of air-bottle.

The filter-pump is now turned on, and the stopcock to the filter-tube slowly opened. As the turbid fluid passes the barium carbonate is retained in the asbestos, and the clear water passes into the filter-flask to be there neutralised by the $\frac{N}{10}$ hydrochloric acid. When all the baryta-water from the air-bottle has been passed through the filter, the filter-pump is kept going for a little time so as to produce a slight vacuum in the air-bottle. The stopcock of the shorter tube in air-bottle is now closed.

Into a small beaker 100 c.c. of distilled water are now put, and its contained CO_2 gas neutralised by adding a drop of phenolphthalein solution, a few drops of barium chloride solution, and then some baryta-water, until a faint pink colour begins to show. Into this fluid in the beaker the rubber end of the long tube of air-bottle is dipped, and the stopcock being now opened, the flush from the beaker runs up the tube into the air-bottle. After 20–30 c.c. have passed in, the stopcock is closed, the air-bottle is shaken, and the fluid then run out by the shorter tube through the filter into the filter-flask. This washing-process is repeated at least once more. The filter-flask is now disconnected, and titration of its contents may there and then be carried out, or the contents may be transferred to a casserole for that purpose.

Standard Solutions required :

1. $\frac{N}{10}$ solution of hydrochloric acid, which has been most carefully standardised. Ten c.c. are employed for each estimation.
2. Baryta-water. This is probably best when about the strength of $\frac{N}{50}$. Before being used, its exact strength relative to the acid must be known. Fifty c.c. are used for each estimation.

Ten c.c. of $\frac{N}{10}$ acid will usually neutralise about 50–51 c.c. of baryta-water. Supposing for the moment that it requires 50–80 c.c. of the baryta-water to neutralise the 10 c.c. of the acid, then 1 c.c. = 0·2205 c.c. of CO_2 at normal temperature and pressure.

Calculation of Result. Capacity of air-bottle = 2650 c.c.; temperature of air collected = 15° C.; baryta-water used = 50 c.c.; $\frac{N}{10}$ HCl put in filter-flask = 10 c.c.; after absorption of CO_2, filtration, and titration of baryta-water from air-bottle, further amount of baryta-water required to be added for neutralisation = 4·50 c.c.

Capacity of bottle minus 50 c.c. of baryta-water = 2650 − 50 = 2600 c.c.

Total baryta-water used = 50 c.c. + 4·50 c.c. = 54·50 c.c.

Amount baryta-water required to neutralise 10 c.c. $\frac{N}{10}$ acid = 50·80 c.c.

Difference in excess baryta-water employed = 3·70 c.c.

The proportion of CO_2 in the air of sample per 10,000 volumes at 15° C. is worked thus :

10,000 vols. of air at 0° C. =10,540 vols. at 15° C.

$$\therefore \frac{3{\cdot}70 \times 0{\cdot}2205 \times 10540}{2600} = 3{\cdot}31 \text{ vols. } CO_2 \text{ per } 10{,}000 \text{ vols.}$$

This method may be employed in samples of air conveyed from a distance provided the Winchester quart bottles are stoppered airtight till analyses are made. Rubber stoppers are best for this purpose, although vaselined glass stoppers also serve the purpose well. (Fig. 35.)

Pettenkofer's Tube Method.—The reagents and standard solutions used are the same as in previous method. The apparatus consists of two tubes *A* and *B*, the one placed above the other, both connected with each other and with an aspirator C, of known cubic capacity by means of tight rubber tubing. 100 c.c. of baryta-water are put into each tube, the connections duly made, and thereupon air is drawn slowly in a series of fine bubbles through the tubes, by opening the tap of the aspirator. The quantity of air to be tested is regulated by the size of the aspirator. At the end of the experiment, the contents of tubes *A* and *B* are emptied into separate, clean, glass-stoppered flasks, to allow precipitates of barium carbonate to subside. Meanwhile, 50 c.c. of stock solution of baryta-water is being titrated against standard oxalic acid, and the number of c.c. required are noted. When the exposed baryta-water has cleared, 50 c.c. of the supernatant clear solution of each bottle are pipetted off, titrated as described, and each result multiplied by 2 ; the sum of both equals, after calculation, the total CO_2 in the total volume of air passed through.

Of the two methods of Pettenkofer this is certainly the more accurate, although the needed apparatus is not so portable in the latter.

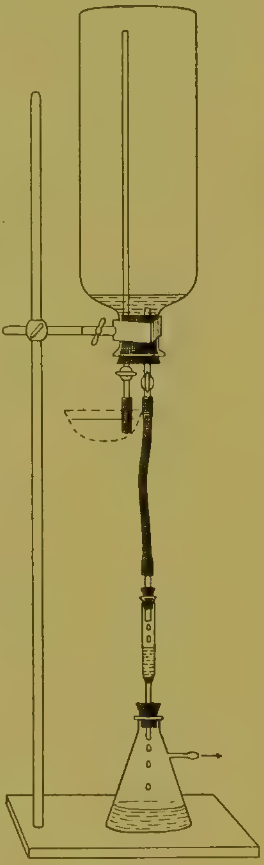

FIG. 35.

Professor Walker of Edinburgh has suggested a modification of Pettenkofer's Flask Method. This consists in using a Winchester quart, the rubber stopper of the mouth of which is perforated to enable two glass tubes provided with stopcocks to be passed. By means of one of these tubes 50 c.c. of $\frac{N}{50}$ baryta-solution are introduced into the bottle, and the air-contents shaken up for about fifteen minutes. After this the Winchester bottle is inverted, and the contained baryta-water passed into a Soxhlet apparatus with asbestos or glass-wool filter connected with a filtering flask charged with 10 c.c. of $\frac{N}{10}$ hydrochloric acid, which in turn is connected with a filter-pump. By means of the filter-pump and stopcocks, the air-bottle is washed out three times with neutralised distilled water, this operation being completed with entire exclusion of atmospheric air. The excess of hydrochloric acid is now titrated back with $\frac{N}{50}$ baryta-water, and the quantity required is the measure of the amount of CO_2 present in the air of the jar, since the carbonate of barium formed is arrested in the Soxhlet filtering-tube, and consequently the alkaline barium-solution is less in valency as is the excess of hydrochloric acid. Walker claims for this process an accuracy which in no case varies on one side or other of the truth more than 0·1 volume in 10,000 of air.

Hesse's Method.—The apparatus consists of *A*, the reserve laboratory portion and *B*, the portable portion.

A consists of (1) *Stock saturated solution of baryta-water*, made by dissolving in 4 to 5 litres of water, 1 kilo. of hydrated oxide of barium, $Ba(OH)_2$, and 50 grammes of barium chloride, $BaCl_2$. As the solution is used to make the working solution, water is added so long as the barium compounds are in excess to saturate the water ; (2) *Working solution* of the same ; the bottle which contains it being provided with absorption-flask containing pumice-stone saturated while hot with heated caustic potash, to arrest CO_2 of the entering air as the solution is siphoned off as needed ; (3) Standard Solution of *Oxalic Acid*, containing 5·6325 grammes pure acid per litre of distilled water, of which 1 c.c = 1 c.c. vol. of CO_2 ; (4) *Alcoholic solution of phenolphthalein*, 1 to 250.

B consists of (1) Five thick-walled Erlenmeyer flasks of $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{12}$, $\frac{1}{16}$-litre-capacity respectively, exact cubic capacity of each of which to lower level of fitted rubber stopper has been carefully ascertained and marked on flask. Each flask is fitted with a 2-holed rubber stopper, the holes being fitted with pieces of glass rod well rounded at lower end and button-shaped at top ; (2) Thick-walled 10 c.c. pipette ; (3) Burette, with glass stopcock, of 25 c.c. capacity and graduated in tenths, having a spit or tip from 7 to 10 centimetres in length ; (4) Flasks of 300 c.c. capacity, provided with absorption-bottles and filled with solution of baryta-water (No. 2 above), to which a few drops of *rosolic acid* have been added to faintly colour the contents ; (5) Bottles of 250 c.c. capacity, filled with oxalic acid solution, made by mixing 25 c.c. of strong acid solution (No. 3 as above) with distilled water up to 250 c.c. : 1 c.c. of solution = ·0056325 gramme of oxalic acid = ·01 c.c. vol. of CO_2 ; (6) Thermometer (Cent.) ; (7) Aneroid or mercurial barometer.

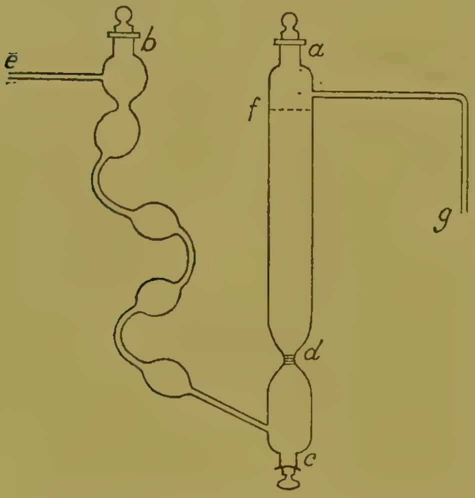

FIG. 36.—Wolff's Apparatus for Testing for Carbon Monoxide.

By this method each determination of CO_2 is made in duplicate, but with different volumes of air. Thus, $\frac{1}{2}$ and $\frac{1}{4}$, or $\frac{1}{4}$ and $\frac{1}{8}$, or $\frac{1}{8}$ and $\frac{1}{12}$-litre flasks are used together, depending upon likely impurity of air.

Modus operandi.—Take samples of air by first filling flasks with water at place of examination and temperature of place, and then emptying them in the room, rinsing with distilled water, and draining dry, care being taken neither to warm flasks with the hands, nor to breathe into them. Then take the stopper of flask to be used, pass through one opening of it a 10 c.c. pipette ; insert point of pipette into delivery-tube of dilute baryta-water ; fill to 10 c.c. mark ; place stopper in position in mouth of air-flask ; drain pipette contents into flask ; then withdraw pipette and quickly close opening with glass rod. Repeat the process with the second smaller air-flask. Allow air-flasks to stand for about 15 minutes or more, with occasional agitation, to absorb CO_2. In the interval, titrate the alkalinity of 10 c.c. baryta-water in $\frac{1}{16}$-litre flask with oxalic acid solution (No. 5 as above) until colour is discharged ; note number of c.c. of acid required. Then proceed to titrate the baryta-water in air-flasks, *without removing barium carbonate formed*, in the following manner :—Remove glass rod from one hole of stopper, quickly insert in its place the long-spitted burette filled to zero mark with oxalic acid solution, titrate carefully, with rotatory motion of flask, until colour is discharged, and note number of c.c. required. Should contents of burette cease to run during the process, gently ease the glass rod of second opening. Proceed with second air-flask in like manner; then calculate results to normal temperature and pressure, and take the mean of results as the amount in volumes of CO_2 present in 10,000 volumes of air of samples. This process, when carefully conducted, gives most accurate results.

Haldane's Apparatus.—This apparatus is of the gasometric type, the amount of CO_2 present in a given volume of air being estimated after absorption by KHO solution. The portable apparatus was designed in connection with the work of the Home Office Committee on Ventilation of Factories and Workshops, and is figured in the Report of that Committee.[1] It is claimed for the apparatus that, being enclosed in a suitable case, it may easily be transported from place to place, that it is always ready for use, and that an accurate result may be obtained within five minutes, no calculations being required. The quantity of air taken into the apparatus is measured at the room temperature, which is to be noted. By manipulating stopcocks on glass tubes and the raising and lowering of the mercury reservoir, the air is washed with KHO solution and freed of its contained CO_2. The original volume of intaken air being now remeasured in the graduated tube, the difference in diminution is the amount of CO_2 absorbed, and, therefore, the amount of that gas contained in the original air. Having experimented largely with the apparatus, we agree with the claims made for it, its only drawback being that, when out of use for a short interval, the caustic potash solution is apt to bind, almost to vitrification, the stopcocks and lead to breakage of the tubes in attempts to release the stoppers.

Detection of small Amounts of Carbon Monoxide in Air.—The best qualitative method is that of Vogel, which is based upon the formation of a compound of the gas with hæmoglobin known as carboxyhæmoglobin. Wolff's apparatus is excellent for the application of the test. It is prepared in the following way: Close constriction at *d* with a plug of glass-wool, fill tube *d* to *f* with glass, powdered as fine as ordinary gunpowder, after sifting, digesting with HCl, washing with water, and drying it; moisten it *in situ* with distilled water; apply water-pump connection at *e*, to drain through surplus water, which is run off by stopper *c*; thereafter, drop over glass powder 2 c.c. of dilute blood (prepared as below) 1 to 20; gently blow through *g* to distribute blood solution evenly through glass powder; attach aspirating vessel of known capacity at *e*, and aspirate through about 10 litres of air at the rate of about 1 litre per 20 to 25 minutes. When room air is being examined, the air ought first to be passed through a glass cylinder containing pumice-stone moistened with water, which may be attached at *g*. When the above quantity of air has been passed, from 3 to 5 c.c. of distilled water should be added to tube-contents at *a*, the aspirator disconnected, and the water-pump connected, so that the blood-solution and added water shall be drawn through into lower part of tube, which may be removed at *c* for spectroscopic examination. After the operation is over, the glass powder should be washed clean with water and drained, ready for other experiments. The blood-solution to be used is obtained by mixing fibrin-free blood with an *equal volume of cold saturated solution of borax*, since by this addition decomposition is prevented, the spectroscopic properties are not interfered with, nor is the action with ammonium sulphide. One c.c. of the mixture added to 19 c.c. of distilled water is the strength to be used, and 2 c.c. are the quantity for each experiment. The above test will detect ·05 per cent. of carbon monoxide in air. The blood is thereafter examined spectroscopically by the direct-vision spectroscope for the characteristic bands of carboxyhæmoglobin (*vide* p. 655, vol. i.). (Fig. 36.)

Methods for Detection of Organic Matter in Air.—(*a*) Wanklyn's method of estimating organic matter in terms of ammonia. Connect with an aspirator of known capacity a wash-bottle containing 50 to 100 c.c. of ammonia-free water, which is placed in ice or a strong solution of ammonium nitrate. Aspirate through the water not less than 5 to 10 litres of air. At end of experiment place contents of wash-bottle, after addition of 100 c.c. of ammonia-free water, into a retort connected with Liebig's condenser, and distil for *free* and *albuminoid* ammonia as in the process for water analysis (*q.v.*). After Nesslerising, calculate results into volumes of air used, and state in terms of ammonia per 100,000 or million volumes of air.

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[1] Parliamentary Paper Cd. 1302, 1902, p. 117.

(*b*) Carnelly's process. Reagents required: (1) $\frac{N}{100}$ solution of $KMnO_4$ = ·316 grammes of salt per litre of freshly distilled water; (2) $\frac{N}{1000}$ solution of the same, made by mixing 100 c.c. of $\frac{N}{100}$ solution with 50 c.c. of dilute sulphuric acid (1 to 10), and making up to one litre with distilled water; (3) Dilute sulphuric acid (1 to 10).

Apparatus required: (*a*) Large air-jars or Pettenkofer's tubes; (*b*) Burettes and pipettes; (*c*) Bellows.

Modus operandi.—Fill air-jar of known capacity with air to be examined; add 50 c.c. of $\frac{N}{1000}$ $KMnO_4$ solution; and wash well, by agitation, air of jar with solution for 5 to 10 minutes. Having prepared two *chemically clean* Nessler or Hehner glasses, *A* and *B*, into *A* put 25 c.c. of $KMnO_4$ solution from air-jar, and add to 100 c.c. mark with distilled water, and into *B* put 25 c.c. of $KMnO_4$ solution from $\frac{N}{1000}$ stock bottle, and add to 100 c.c. with distilled water. Compare the colours in the glasses. There will be decolorisation in *A* in proportion to amount of oxygen used up by organic matter of air in air-jar, or the amount of air passed through the Pettenkofer tubes, if such have been used instead of an air-jar. From a burette charged with $\frac{N}{1000}$ $K\,MnO_4$ drop into glass *A*, with stirring, such a quantity as will make colours of *A* and *B* exactly alike. The amount added will be half the measure of oxygen used up. Multiply the number of c.c. required by two, and the answer by ·0056 to bring oxygen to volumes; calculate the result into one million volumes of air examined. Thus: suppose 25 c.c. solution from air-jar required 3 c.c. of $\frac{N}{1000}$ solution to make colours in *A* and *B* alike; then $3 \times 2 = 6$ c.c. for total solution used, and $6 \times {\cdot}0056 = {\cdot}0336$ volumes of oxygen used up by air-contents of jar. But the capacity of air-jar is 3500 c.c. less 50 c.c. air-space taken up by solution added—viz. 3450 c.c.;

then 3450 c.c. : 1,000,000 : : ·0336 : x
$\therefore x = 9{\cdot}74$ volumes of oxygen per million volumes of air required to oxidise organic matter present.

Corrections must be made for temperature and pressure. The above test when used for testing the air of a room in which artificial lights, other than electric, have been used, is open to the objection that decolorisation of the permanganate solution is affected by oxidisable products of combustion, and, therefore, the result cannot be taken to be truly representative of organic matter given off from the bodies of the occupants. Moreover, it is sometimes difficult to exactly match the colours. At the same time, the test is probably the best available for estimating organic matter in air.

CHAPTER V

HEATING AND LIGHTING

THE sources of heat in occupied apartments may be summed up under the following—viz.

(*a*) Open Fires, which consume coal or wood;
(*b*) Closed Stoves, which consume coal, wood, or oil;
(*c*) Gas Fires;
(*d*) Hot-water Installations, at ordinary pressure;
(*e*) Hot-water Installations, at high pressure;
(*f*) Steam-coils.

(*a*) *Open Fires.*—The open fire still holds, in this country at least, the premier position as the source of heat in houses. It sends out radiant heat which is stimulating and exhilarating; this warms the objects which it strikes—the bodies of the occupants, objects of furniture, walls of room—and the room to a greater or lesser extent is thereby warmed. It least of all directly warms the air. It is without question the most healthful form of heating, for not only does it provide heat, but it also gratifies the senses as no other form can. The objections, from the economical point of view, which have been urged against it, and with much truth, are: (1) that its heating effect is most unequal, since the intensity of radiant heat is in direct proportion to the temperature of its source, and inversely as the square of the distance from the source; hence the greatest amount of heat is in the immediate vicinity of the fireplace; (2) that it is most wasteful of fuel with relation to the amount of heat given off into the room-atmosphere; indeed, in an ordinary fireplace it may be reckoned that from five-eighths to three-fourths of the total heat generated is of no value to the apartment. From the economic standpoint these are cogent objections. Probably the first objection will always more or less obtain, no matter the kind of fireplace used, or the mode of consumption of fuel which is adopted. (Fig. 37.) But improvements may be instituted to remedy the objection with respect to unnecessary waste of fuel. This waste is due to two factors chiefly — viz. (*a*) faulty construction of fireplace, grate, and throat of chimney, and (*b*) the mode of consumption of fuel. In ordinary use, probably about one-third of the coal passes off in smoke which produces no heat, but only assists in contaminating the general atmosphere outside. This may be called active or *quick* combustion, as contradistinguished from *slow* combustion which is accomplished by

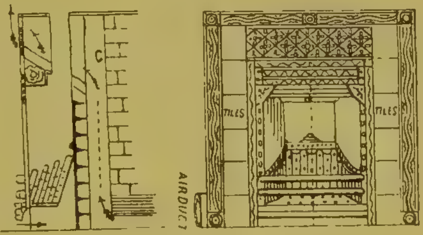

FIG. 37.—Griffin's Grate.

regulating the amount of air to be supplied to and which is required by the fire for combustion. In ordinary or quick combustion, the air-supply passes through and from beneath the fire-seat; in slow combustion, it is only permitted to pass through the fire-seat. In consequence of the reduced air-supply, combustion is less rapid, the fuel lasts longer, and the air-movement in the flue is slower; so that for a smaller quantity of fuel, a larger amount of heat is conserved for heating the apartment. From a long-continued series of practical experiments with different forms of grates, we have found that not only is the slow-combustion grate the most economical of fuel, but that more heat per unit of fuel is given off into the room. The simpler the form of grate the better. We devised the following grate for an apartment of about 6000 cubic feet capacity. It consisted of a plain metal frame placed "flush" with the wall of the room. The floor was composed of one large thick firebrick, and the sides and back were formed in the same way. The outer lining of the fireplace, behind the side and back bricks, was built up of fireclay bricks set in cement. The throat of the flue was contracted and rounded in cement. To start the fire, a blower which consisted of a sheet of iron, was made, which fitted into a sliding socket in the upper part of the grate-frame, and which could be pulled down when required, and replaced when the fire was started. Such a fire required to be replenished but twice daily; and even after it was out, much heat was given off from the fire-bricks. Another advantage of the slow-combustion grate is that objectionable draughts are less likely to be produced between the windows and door and fireplace. While these grates would not be an absolute cure for smoky atmospheres, there is no doubt that smoke-production would be greatly reduced. Other forms of grates have been devised with the avowed object of smoke-prevention. Fig. 38 shows one form in which the fresh coal is placed in the fire by a specially constructed shovel on the curved ledge shown in the section below the incandescent coal. Next to petroleum, coal gives off per unit more heat than any other form of fuel.

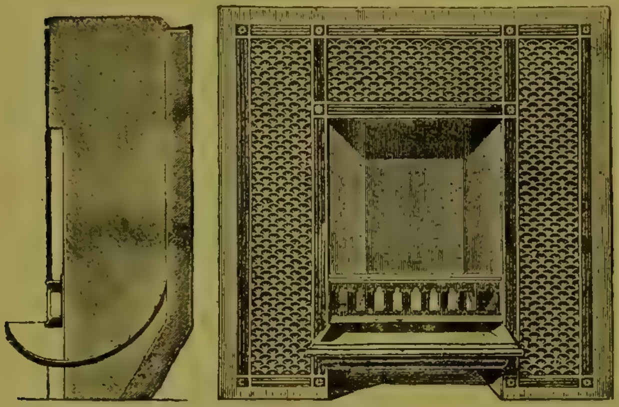

FIG. 38.—Brown and Greene's Grate, to aid in smoke-consumption. By means of a specially constructed shovel fresh coal is put into the fire, on the curved ledge shown in the section, below the incandescent coal.

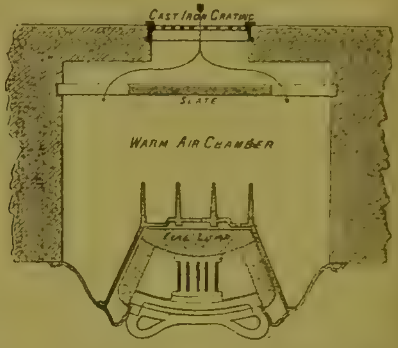

FIG. 39.—Section of Galton's Grate. Through the grating behind the fireplace passes fresh air, which being warmed by the heat of the fire in the grate, passes into the apartment.

(*b*) *Closed Stoves.*—To some extent these are used in this country, but they are more commonly employed in countries which experience more rigorous winters. They economise fuel. They, however, warm the air of the room more than the objects in it, and they do not act so efficiently as exits for foul air as the open grate. They are made of cast-iron, either solely, or with an external covering of porcelain slabs or tiles. Such stoves are by no means impervious to the gases of combustion, not only from the loosening of the joints and seams consequent upon alternate expansion and contraction, but when red hot they are pervious to carbon monoxide. The source of this gas is still an open question; it is doubtful whether it is due to imperfect combustion of the coal, to the oxidation of the organic matter of the air coming in contact with the heated metal, or to the combustion of the carbon contained in the iron of the stove itself; all of these causes have been suggested. Probably the chief objection to the use of stoves lies in the fact that they "dry" the air of the room; in other words, they produce upon the occupants the sensation of dried air. The effect is by no means imaginary, and is caused in the following way. As we have already seen, the quantity of watery vapour in the air at any given time is dependent upon the temperature of the air; in other words, for each temperature there is a maximum amount which the air can sustain, called the *saturation-point*. Most commonly, however, air only holds some percentage proportion of this; and most comfort is experienced when that proportion is from 70 to 80 per cent. If we assume that when a stove is lighted, the temperature of the air of the room is 40° F., and that it then holds 75 per cent. of watery vapour for that temperature, when the room temperature has risen to 65° F., the percentage of humidity for *that temperature* will become less than 75 per cent., since the total amount of watery vapour capable of being sustained increases with rise of temperature; consequently, the air feels dry to the occupants. What happens, then, is this. The air robs the bodies of the occupants of moisture to satisfy its needs, and hence the skin begins to feel dry, the hair crisp, and an indefinable sense of discomfort supervenes. This is commonly overcome by placing shallow vessels containing water in the vicinity of the stove.

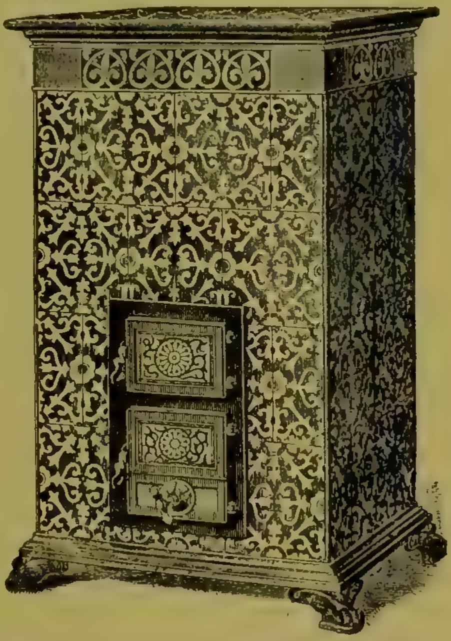

Fig. 40.—Doulton's Tiled Stove. *Vide* Fig. 21 for section-plan of stove.

(c) *Gas Fires.*—It may be conceded at once that gas fires are handy, cleanly, and comparatively cheap as sources of heat. For cooking purposes, especially in summer, they can be used as needed, and so they save the needless expenditure of coal fuel. But as a source of heat in rooms, except in bedrooms where they are used only for a short time before retiral to bed, we are decidedly against their use. We have tried practically many forms, but have discarded them all. All the objections which have been offered against coal stoves have greater force against these, not only from the point of view of efficiency, but chiefly from that of health. Perhaps the least objectionable form is that in which a series of Bunsen jets is fitted into an ordinary grate filled with chunks of asbestos or fire-clay, since some of the radiant heat of the coal-fire is provided, and there is an ample flue for the escape of the products of combustion. The same, however, cannot be said of those gas-heaters which are provided with flue-pipes of one-half to one inch diameter only. Such flues are worse than useless; indeed, they are delusive and dangerous, especially where coal-gas contains an admixture of water-gas, or of carburetted gas which is rich in carbon monoxide, because of the inadequate provision for carrying away the products of combustion or unconsumed gas due to a choked burner or one which has struck back. Flueless gas stoves are positively harmful, unless sufficient provision be made to neutralise by absorption the resultant gases of combustion. Those which profess to do this are still on their trial; and until some special provision has been made to absorb carbon monoxide, which is exceedingly poisonous, and at the same time odourless, they cannot be deemed safe or healthy. Acetylene is liable to be given off from gas fires where the Bunsen burners become choked, or strike back. This gas is very irritating to throat and lungs, and is apt to exercise prejudice to the health of those exposed to it. This, however, is not an objection to the use of gas as a fuel, but to its improper use. At the same time, the generation of acetylene is very common from want of attention, while its rectification is easy. Upon the whole, it appears to us that the drying of the air is greater with gas fires or stoves than even with coal stoves. The special field of usefulness of the gas fire is that of cooking.

Oil stoves are objectionable also from the health point of view. There is no practical difference between burning several wicks under cover of coloured glass and burning several single lamps; they equally consume air, and for equal quantities of heat consume more oxygen than coal-gas. Besides, they are usually unprovided with flues of any kind, and are calculated, therefore, to charge the atmosphere with excess of CO_2. Another objection to their use is the disagreeable odour of acrolein which is produced by the combustion of poor oils, or of oil in an imperfectly cleaned stove.

In short, all stoves heat the air of the room by conduction; the open fire, by radiation. The former do not act as efficient outlets of foul air—indeed flueless stoves, not at all; the latter acts more or less efficiently. Whatever faults the open fire possesses, it is much superior from the point of view of health than any kind of stove.

(*d*) *Hot-Water Installations: At Ordinary Pressure.*—Heating by pipes containing hot water about a temperature of 180–200° F. is in common use in large public buildings, such as halls, churches, hospitals, schools, barracks, and the like. It is coming into use, however, in large private dwellings. The heated pipes, which are composed of cast-iron, warm the air of the apartment by conduction, or convection. Provided special arrangements are made for the ventilation of the apartments, little or no objection can be offered to their use. The only precaution which requires to be taken is that the contents of the cold-water supply-cistern should be prevented from freezing. Such an occurrence is by no means unknown. Moreover, in view of possible cessation of the public water-supply for a period of time, it is advisable to have a reservoir-cistern to fall back upon when needed. In the system, the boiler is the lowest point, and the circulation depends upon the fact that heated water becomes lighter and rises, cools in passing along the pipes, and falls by gravity back to the boiler. The allowance for heating surface per thousand cubic feet of air to be heated is twelve feet of 4-inch piping. Hood, in his treatise on Warming and Ventilation, shows that one foot length of a four-inch pipe containing water at a temperature 125° F. above that of the surrounding air will raise 222 cubic feet of air one degree of temperature per minute—that is, about 190 cubic feet for every superficial foot of surface of pipe. In order to calculate the necessary extent of piping required to heat any given confined space, he recommends that the total cubic space in feet be multiplied by the number of degrees of temperature desired, and that the product be divided by 190 into the time, reduced to minutes, within which the desired temperature is to be attained; the answer will be the number of superficial feet of pipe required. Careful allowance must, at the same time, be made for windows and open ceilings. When a temperature of 60° F. above that of the external air is wanted, the rule is to add one foot of piping for every two and a half feet of glass superficies.

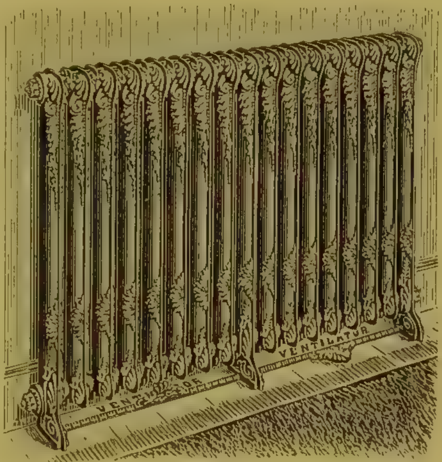

Fig. 41.—Hot-Water Radiator.

(*e*) *At High Pressure.*—This form of installation, in which the water is heated under a pressure of three or four atmospheres, is fitted with pipes of smaller diameter than in the previous system, which are made of wrought-iron. They are thick in the wall and their internal diameter is half-an-inch. The pipes form a continuous system, shut off from the air, except at the highest point, where an expansion branch-pipe is placed to prevent explosions. There is no boiler in the system, the water being heated by a length of the pipe, usually from about one-tenth to one-sixth of the total, placed in the furnace. The temperature of the water is usually about 300° F. By reason of this, the extent of piping required is less than in the other system. It is commonly estimated that 8 or 9 feet of piping is equivalent in heating-power to 12 feet of the other.

(*f*) *Steam-Coils.*—Steam is also used in pipes for warming purposes, and either at high or low pressure. In workshops and factories where steam-power exists, the waste steam is usually employed for this purpose. The size of pipe to be used necessarily depends upon the area to be warmed. Connected with the steam-pipes, at suitable points radiators are placed. In these, the calibre of the pipes is purposely made larger than that of the supply-pipe, so as to favour condensation and thus favour the liberation of latent heat; but it is necessary that facilities be provided for the rapid return to the boiler of the condensed vapour. Probably the only large experiment of heating the homes of a community by steam is that which was carried out in Lockport, America. The steam can be turned on and off at will in each house in the circuit, and it can be employed for heating or cooking, or as a motive power. In all of these systems by hot water or steam, valvular arrangements exist at suitable points whereby the circuit can be closed, or the circulation regulated. Where such systems are installed it is necessary to have separate arrangements for ventilation.

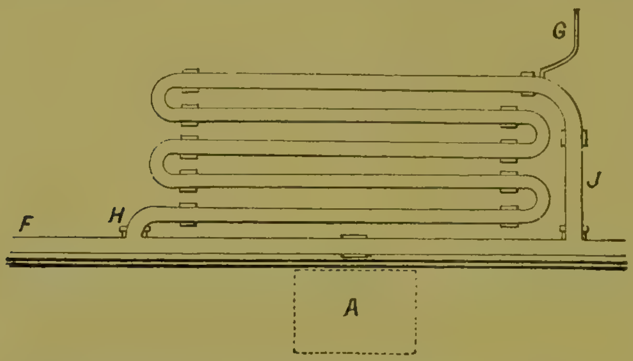

Fig. 42.—High-Pressure Hot-Water Coil for heating air of apartment and also incoming fresh air at A. F, main hot-water pipe; H, J, branch coil-pipe; G, expansion-pipe.

The Reck system combines the low-pressure hot-water and low-pressure steam systems, and is held to overcome the disadvantages of both. The essential parts of the system are these: (1) the steam-boiler; (2) the reheater; (3) the condenser; (4) the circulator; (5) expansion-tank; and (6) the circulatory pipes and radiators. It is a closed system like the ordinary hot-water system.

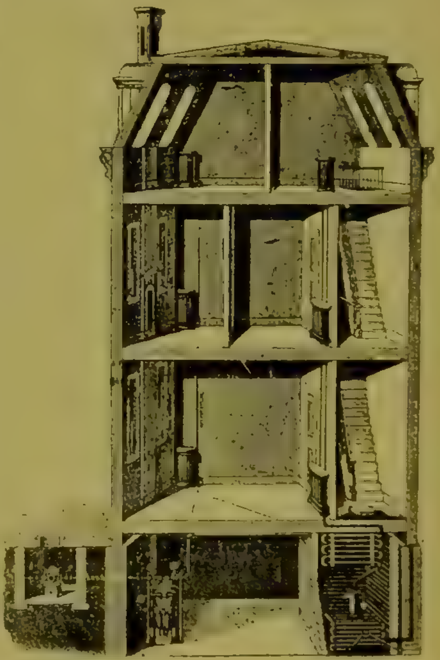

Fig. 43.—System of Heating Houses by Steam.

The boiler in which steam is generated is automatically controlled, and a pressure of about five pounds only is required to work the system. The steam is used to heat the water in the circulatory pipes and radiators, and also to accelerate the velocity of circulation of the heated water therein. From the boiler the steam enters by a pipe into a coil contained in the "reheater"—a small tank filled with water connected with the water-filled circulation-pipes—and through this coil its water-contents are heated. From the top part of the reheater passes the rising main hot-water circulating-pipe. The temperature of the water in the reheater and rising main can be heated through the agency of the steam-coil to a temperature of 185° F. The rising hot-water main pipe, in rising upwards to the expansion-tank—which is the highest point of the heating system—passes through the condenser, which is formed like a jacket round the main pipe, and then through the "circulator," before reaching the expansion-tank. From the top of the reheater passes a steam-pipe to the circulator, which lies below the expansion-tank. The steam, which is thrown into the circulator, is broken by a diaphragm into small streams at the point of mixing with the ascending water, raises the temperature of the water in the uprising main-pipe on its way to the expansion-tank, and, being mixed with the water, on reaching the expansion-tank is partly disengaged from the water into the upper levels of the tank, from which it escapes by a pipe leading down to the condenser, and being there condensed returns in a pipe to the lower part of the boiler by the influence of gravity. The object and intention of the steam-pipe to the circulator are to give additional heat and, therefore, impetus to the hot-water flow near the highest point of the system where the flow is apt to be slowest and requires assistance. By the acceleration thus given to the flow where it is most needed, the difficulties met with in low-pressure hot-water systems of sluggish flow owing to length of pipes from and to lack of height over the boiler are overcome. From the bottom of the expansion-tank, which is a steam-tight tank, passes the main flow-pipe of the circulatory pipe system, from which branches supply the different radiators. The return water of the system is brought back to the reheater by a return main-pipe, and thus the complete circulation of flow is made. The pipes used in this system are only half the diameter of those employed in ordinary low-pressure hot-water systems. The radiators, which may vary in size according to the amount of heat desired at the required points, are placed where they are wanted.

It is claimed for the system—a claim now well established—(*a*) that no water-supply cistern at the top of the building to feed the boiler is necessary, as the boiler can be fed directly from the water-main connection at the lower level; (*b*) that the risk of freezing of supply is thus reduced to a minimum; (*c*) that over-heating of boiler and explosion are absolutely impossible; (*d*) that the system being entirely automatic can be worked by an unskilled attendant; and (*e*) that it can be installed and maintained at less cost than ordinary systems. The system, having been installed for some years in the new Dispensary of the Western Infirmary, Glasgow, has proved an unqualified success.

In America especially, and in other countries, the use of warmed air supplied from hot-air furnaces is very prevalent. The furnace is usually situated in the basement, and from it hot-air flues are distributed through the various apartments. While in this country most comfort in winter is attained by a temperature of about 65° F., it would appear that in America that is effected by one of 70–75° F., by reason of the less humid condition of the atmosphere. Water vessels, however, are usually necessary in the apartments, because of the dryness of the air which is produced.

LIGHTING AND ILLUMINANTS

Lighting.—Of the artificial illuminants now in use, the principal in the order of prevalence are the following—viz.

(*a*) Coal-gas;
(*b*) Oils—burned in lamps;
(*c*) Electric light.

In the two first-named, the illumination is produced by the combustion of inflammable gases or vapours; in the last, from the passage of an electric current which, by reason of resistance offered to its further progress, raises a carbon filament to a state of active incandescence, or carbon pencils to a white incandescence. In the last, the amount of combustion is but small. The consumption of coal-gas and of the hydrocarbons of oils mainly produces carbonic acid and water; if, however, the gas be imperfectly purified, traces of sulphur gases and ammonia are also found. During combustion they use up the oxygen of the air. Electric lighting is not accompanied by any consumpt of oxygen and, therefore, unlike the others, does not contribute to the vitiation of the atmosphere, inasmuch as no carbonic acid is produced.

(*a*) *Coal-Gas.*—This is composed of a mixture of gases, which may be divided into illuminants, diluents, and impurities. Of the first, the chief are ethylene, propylene, acetylene, and benzene; of the second, hydrogen, marsh-gas, carbon monoxide; and of the last, nitrogen, carbon dioxide, sulphuretted hydrogen. In 100 parts, the first form about 6·5 parts, the second about 90 parts, and the last about 3·5 parts. The exact composition of coal-gas depends upon the character and quality of the coal from which it is made; that from cannel coal being richer in illuminants than that from bituminous coal. Of the illuminants the principal is ethylene, or, as it is more commonly termed, carburetted hydrogen or olefiant gas. The products of the combustion of gas per 100 parts are composed as follows:—nitrogen about 67 per cent.; water, 16 per cent.; carbonic acid, 7 per cent.; carbon monoxide, 6 per cent.; in addition to traces of sulphurous acid and ammonia. The chief results of the use of coal-gas upon the air of rooms are increase of carbonic acid and watery vapour, heightening of temperature, together with the production of carbon monoxide, and, when improperly consumed, the passage of unconsumed constituent gases and unconsumed carbon into the room atmosphere. It exercises, moreover, a destructive influence upon articles in the room, as books, pictures, wall-paper, etc., and is not cleanly. Each cubic foot of gas consumed may be reckoned as polluting the atmosphere to the same degree as one adult, since it gives off half its volume (0·52) of CO_2 and 1·34 cubic feet of watery vapour. Many ingenious contrivances in the form of improved burners to ensure the regulation and better consumption of gas have been devised, and some of these have been associated with ventilating flues by which the products of combustion are carried out of the apartment. In the regenerative gas-burner of Siemens, there exists an arrangement whereby, in a chamber heated by the products of combustion, air and gas are warmed prior to their admixture and ignition. After the products have become heated in the mixing-chamber they are discharged into the open air. Probably the best form of gas consumption is that attained by the Welsbach incandescent light. It consists essentially of a Bunsen burner, surmounted by a mantle of fine network composed of asbestos which has been treated with a solution of a zirconium salt. The mantle, by reason of the intensely hot non-luminous flame of the Bunsen, becomes incandescent and emits a brilliant white light, and for equal quantities of gas consumed gives more than one and a half times the light of the Siemens burner. The introduction of pendent lights fitted with small mantles has done much to give a new lease of life to gas as a lighting medium. It is now being introduced into street lighting.

Since coal-gas has become so much used for heating purposes, various towns in this country and in America have added certain proportions of water-gas or of carburetted water-gas. This has given rise to many fatal accidents, because of the large proportion of CO_2 which it then contains. (*Vide* vol. i., p. 651.)

Water-gas or producer-gas is made by passing air and steam through incandescent coke or other carbonaceous fuel at a temperature of about 2000° F., the oxygen of the air and steam uniting with the carbon of the fuel to form a gaseous mixture of which carbon monoxide is one of the chief ingredients, amounting to about 47 per cent.

Carburetted water-gas is made by fortifying water-gas with volatile hydrocarbons.

Acetylene gas, C_2H_2, generated by the action of water upon calcium carbide, is now becoming adopted for small installations of lighting. Its use is not unattended by danger from risk of explosions due to admixture with air in proportions of from 4 to 25 per cent., but doubtless this risk will be overcome. It gives a strong, clear, white light. The products of combustion are solely CO_2 and watery vapour.

(*b*) *Oil-Lamps.*—Good oils burned in suitable lamps give an exceedingly good, mellow light, although they all raise the temperature of the room air on combustion, and give off much CO_2 and watery vapour. Kerosene oil, in addition, however, contributes traces of sulphurous acid. Oil is much used in the country and in small towns as a matter of necessity, and by many persons in populous places, as a matter of choice.

(*c*) *Electric Light.*—If the prime cost of installation and cost of generation of the electric light could be reduced, it would become the prevalent light of private houses as well as of the public streets, for undoubtedly it presents enormous advantages over the other illuminants from the point of view of health. In the first place, as there is no consumption of the air of the apartment, so are there no vitiated products returned to it; and in the second, during its operation, but trifling heat compared with other illuminants is generated. According to certain authorities, small quantities of nitric acid are produced from the arc light. Of the two systems of lighting—viz. the incandescent and the arc, the former is more adapted for the lighting of apartments, the latter for public halls and streets. The former possesses a mellow, yellowish light which is more agreeable to the vision than the arc light, which is white and dazzling, and which, moreover, is rich in the violet and ultra-violet rays of the solar spectrum. There can be little doubt that by the more general use of the incandescent system of electric lighting, the health of persons, who, by employment or otherwise, are exposed for hours together to artificial illuminants, would be better conserved than at present, and more general comfort would be ensured. Since the introduction of this form of lighting into a church frequented in the evenings by crowded audiences, the number of fainting attacks, which when coal-gas was in use were very common, has now been reduced to a minimum; moreover, there has been a substantial reduction in the temperature, and in the sense of oppression of the atmosphere from the former time. In the use of electric light, special provisions must be made for ventilation, since in the absence of the generation of heat by the lighting, the motive power of the other illuminants is absent; however, coal-gas may be used as a sunlight-burner at the mouth of an outlet ventilator situated on the roof-ridge, in the case of halls, churches, and the like, since, up till now, the installation of coal-gas is maintained alongside that of electricity. However, the advantages produced by electric lighting far outweigh any possible disadvantage, and are vastly superior to those of any other illuminant.

The following table presents some of the chief comparative characteristics of the principal illuminants.

TABLE XXXI

TABLE ILLUSTRATIVE OF ILLUMINANTS

Illuminant	Amount consumed	Candle-power	Cubic Feet of Used-up Oxygen	Cubic Feet of CO_2 produced	Moisture produced	Heat Calories produced
Tallow Candles .	2200 grains	16	10·7	7·3	8·2	1400
Sperm Candles .	1740 ,,	16	9·6	6·5	6·5	1137
Paraffin-Oil Lamp .	992 ,,	16	6·2	4·5	3·5	1030
Kerosene-Oil Lamp	909 ,,	16	5·9	4·1	3·3	1030
Coal-gas Jet, No. 5 batwing burner .	5·5 cub. ft.	16	6·5	2·8	7·3	1194
Coal-gas, Argand burner . .	4·8 ,, ,,	16	5·8	2·6	6·4	1240
Coal-gas, Siemens burner . .	3·2 ,, ,,	32	3·6	1·7	4·2	760
Coal-gas (Welsbach incandescent light) . .	3·5 ,, ,,	50	4·1	1·8	4·7	763
Electric Incandescent . .	0·3 lb. coal	16	0·0	0·6	0·0	37

This table, which we have taken from Notter and Firth's treatise on Hygiene, p. 141, shows the following comparative facts—viz. (1) that for equal candle-power light the Welsbach light uses by far the least gas, uses up less oxygen, and gives off least CO_2, of all the gas-lights; (2) that oil-lamps use up more oxygen, and give off more CO_2, than gas-lights, for equal candle-power; (3) that electric light neither uses up oxygen, nor gives off CO_2; (4) that for equal illumination, coal-gas as ordinarily consumed gives off most heat after tallow candles, oil-lamps next, then the Siemens and Welsbach lights, and electric light least of all.

CHAPTER VI

WATER AND WATER-SUPPLY

Water, like air and food, is one of the prime necessities of life, animal and vegetable. It enters into the composition of everything in nature. The human body itself is made up of 75 per cent. of water, hence the daily individual need is not inconsiderable. Water is a potent factor also in personal, domestic, and public hygiene; hence the need for an abundant supply. The public health largely depends upon a good supply and the free use of water; and a water famine is disastrous to the health of a city, as it is also to the public economics, since so many trade processes, not to speak of steam-raising, require daily much water. Where, too, the carriage of sewage depends on the water-supply, reduced supplies mean imperfect flushing, and, therefore, impurity of sewage-channels, and consequent risks to health. Chemically pure water does not exist in nature, although it is found approximately pure.

Sources of Supply.—The original source of all the water on the earth's surface is the ocean. From the surface of the sea the heat of the sun drives off by evaporation huge quantities of watery vapour into the higher reaches of the atmosphere, which are there condensed as clouds, and returned to the earth as water, either in the solid or liquid form. Having fallen upon the surface of the earth, it depends upon the configuration of the land upon which it falls, and upon its geological structure, whether the rain mainly sinks into the earth, or collects upon its surface. But in any case there is formed an underground or subsoil collection of water, and also an overground or surface collection; the level of both at any given time depending upon the antecedent rainfall. By digging a shaft into the earth, this underground supply may be tapped, but the depth of the well so formed will depend upon the level of the underground water. That part of the rainfall which does not percolate into the soil forms lakes and rivers. Springs arise from the underground water, which, in the course of downward percolation, encounters an impervious rock stratum, which, dipping out on the surface of the land, causes the water to travel along its upper level, and thus to appear at the earth's surface. Water-supplies are obtained from the following sources—viz. (1) rivers; (2) lakes; (3) springs; (4) wells, and (5) rainfall (directly). These demand separate consideration.

Rivers.—In its virgin condition, a river is but a moving column of rain-water, containing in solution what the water may have dissolved in its passage through the air, on its way to the river in the various rivulets or contributaries, and in the river-bed itself. In such a condition, a river is a good source of supply. Hence rivers are tapped as water-supplies; less, however, now than formerly, owing to increasing pollution of streams. But those which pass through moorland, high-lying, uninhabited tracts of country are still available, and afford excellent supplies. London still depends to a large extent for its supply upon the Thames and its tributaries. Aberdeen is in a like position with respect to the Dee; and many other towns in addition. Most rivers, however, with the exception of those parts of their courses above-named, are so polluted by sewage and trade refuse that they must be looked upon as suspicious sources of supply, and before the best of them even can be used, efficient filtration must precede distribution for consumption. There are those who contend that a river will purify itself of organic pollution in the course of its flow. The Rivers Pollution Commissioners in their sixth Report state quite decisively "that there is no river in the United Kingdom long enough to effect the destruction of sewage by oxidation." We shall return to the question of river-pollution later.

Lakes.—These are natural upland collections of water, and constitute the source of our purest supplies. Located in high-lying, sparsely-inhabited areas, they are little liable to contamination; formed on rock strata difficult of solution, they contain but little mineral matter; constituted only of water from the rainfall, their waters are soft, and therefore excellent for washing purposes; but, surrounded by large areas of bogland and moorland, they usually contain vegetable organic matter from the decomposing peat, etc., which, in some cases at least, exercises a plumbo-solvent action on the service-pipes, and also imparts some degree of colour to the water. *Reservoirs* are but artificial lakes, formed in similar districts for similar reasons. They are formed by building an artificial embankment at a suitable point, which impounds the water of one or more small streams. These are constructed of such a size as to contain a sufficient quantity of water to supply the inhabitants of the district to be supplied for a period of 150 to 180 or more days. In all such cases, since the flow of water to down-stream consumers is seriously interfered with, Parliament insists that compensation water, to the extent usually of one-third of the total quantity impounded, must be allowed to pass by into the river, to ensure constancy of which supply compensation-reservoirs must usually be formed. The institution of such reservoirs as a source of water-supply involves very important engineering questions, not only with respect to compensation water, but also with respect to the size of the reservoir to be constructed, since it includes consideration of such important points as the following—viz. (*a*) suitability of site; (*b*) sufficiency of supply, depending upon the mean annual rainfall of the district for a series of years, and the maximum and minimum rainfall, and upon dry weather and mean flow of streams impounded; (*c*) amount in gallons to be supplied per head of population per day; (*d*) number of days' supply to be stored; and several others. From the public health point of view, the important questions are: (1) sufficiency of supply, (2) number of gallons per head per day to be allowed, and (3) number of days' supply to be stored. To estimate the number of days' supply which must be stored, where the source of supply is the rainfall, Hawksley's formula is applied—viz.

$$x = \frac{1000}{\sqrt{y}}$$

where x = the number of days required ;
y = the mean rainfall of the three lowest consecutive years.

Example.—Mean annual rainfall = 50 inches ; loss by evaporation = $\frac{1}{5}$ of annual rainfall.

$$\therefore x = \frac{1000}{\sqrt{40}} = \frac{1000}{6{\cdot}32} = 158 \text{ days.}$$

The total quantity of water yielded by a catchment-area of known size, or the acreage required for a given needed daily supply, the rainfall also being known, may be computed by Pole's formula—viz.

$$x = 62\,A\left(\frac{4}{5}\,R - E\right)$$

where x = the total yield of water in gallons ;
A = the area of gathering-ground or catchment-area in acres ;
R = the mean rainfall of the three lowest consecutive years ;
E = the loss of water by evaporation, waste, and percolation.

A fuller explanation of this formula may be rendered thus :

$$x = 62A\ (\tfrac{4}{5}\,\mathrm{R}).$$
$$\text{or } x = 62A\ (\mathrm{R} - \mathrm{E}).$$

In a rainy district, $150x$ or $G = 62A\ (\mathrm{R} - \mathrm{E})$.
In a dry district, $200x$ or $G = 62A\ (\mathrm{R} - \mathrm{E})$.

Example.—20,000 gallons are needed as a daily supply, the mean rainfall of the three lowest consecutive years being 50 inches. Find the area of gathering-ground required in acres.

A rainfall of 50 inches indicates a rainy district ; therefore the first part of the extended formula is taken—viz.

$$150x = 62A\ (R - E). \qquad 50 \times \tfrac{4}{5} \text{ or } {\cdot}8 = 40 \text{ inches.}$$
$$\therefore \frac{20{,}000 \times 150}{62 \times 40} = 1209{\cdot}6 \text{ acres.}$$

Supposing, however, that the mean rainfall of the three dry years, or R, was only 20 inches per annum, then the second part of the formula would be used :

$$200x = 62A\ (R - E). \quad 20x \times {\cdot}8 = 16 \text{ inches.}$$
$$\therefore \frac{20{,}000 \times 200}{62 \times 16} = 4632 \text{ acres.}$$

The amount of loss by percolation will obviously depend upon the character of the soil, and may therefore vary between 10 and 20 inches per annum ; but in most localities of the upland type it is nearer the lower than the higher figure. For every inch of rain 101 tons, or 22,617 gallons, of water fall upon one square acre of land.

Many important cities derive their water-supplies either from natural or artificial upland lakes ; of these Glasgow, Edinburgh, Manchester, Liverpool, Dublin and others may be cited. The source is often at great distance from the point of distribution ; in the case of Glasgow it is about 30 miles, of Manchester 90 miles, and of Liverpool 68 miles.

From the reservoirs, the water passes by outlet-pipes into the aqueducts, either direct to the place of distribution, or to secondary reservoirs within a few miles of that point, in which latter case it is passed from the secondary reservoirs by distributing mains through the streets of the area of distribution, from which houses are supplied by service-pipes.

Springs.—These usually supply but limited amounts of water, sufficient in quantity, however, in many cases to be a source of storage and supply for limited collections of houses.

Wells.—These constitute the chief source of water-supply of isolated houses, of rural districts, including farms, and even of some small towns. The purity of the water of farm wells is of prime importance with relation to the milk-supply and the spread of enteric fever. Wells may be divided into three kinds—viz. (*a*) Shallow or Surface; (*b*) Deep; (*c*) Artesian; and these designations do not depend so much upon their actual depth as upon their relation to the earth strata through which they are driven. A shallow or surface well is one which, sunk into pervious soil, taps the underground water which has percolated from the surface of the ground within the immediate vicinity of the well-shaft. A deep well is one which, sunk through the pervious surface-layer of soil and an underlying impervious stratum of rock, taps the underground water which has percolated from the land-surface at some distance from the well-shaft. An Artesian well (so called from the province of Artois in France, where they were first discovered) is one in which the shaft is sunk through (1) a pervious layer, (2) an impervious layer, and which taps a collection of water lying on the top of (3), another impervious layer or rock, the two latter of which "outcrop" on the land-surface at a higher point than the top of the shaft, and, it may be, at a distance of many miles from the shaft or bore. The conditions in which an Artesian well is possible, or likely, are these: (*a*) that a water-carrying layer, depressed in the centre and reaching the ground surface at the extremities of the dip, should be situated between two impervious strata; (*b*) that this porous water-bearing layer is not interrupted by any impermeable wedge; (*c*) that there is no source of escape of the contained water in the impermeable layers; (*d*) that the level of the ground at which the boring is made is not higher than the extremities of the water-bearing layer. It will thus be seen that the geological conditions necessary are those of cup-shaped formation.

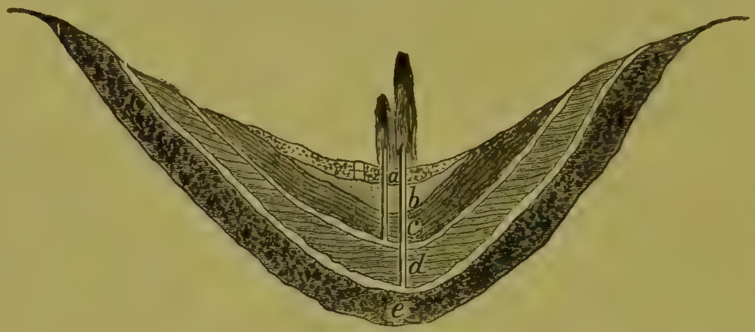

Fig. 44.—Represents a vertical section of Geological Strata of a water-bearing Basin. *a*=layer of loose sand and gravel; *b*=bed of clay; *c*=stratum of slate; *d*=limestone stratum; *e*=a stratum of granite. The upright shafts are spouting bore-tubes or Artesian wells.

The same geological conditions obtain in the case of spouting oil-wells, if an oil-bearing stratum be substituted for the water-bearing stratum. The water which is tapped in Artesian wells falls upon the area of land covered by the water-bearing porous layer, and sinking into this basin-like formation, lies there under considerable pressure. When the bore-tube, in the process of sinking, reaches the water-bearing layer, the pressure on the masses of water lying between the impervious layers forces the water up the tube, and occasionally into the air above the level of the head of the bore-tube. Such wells are commonly of great depth; that of Grenelle, in Paris, is 1800 feet; of Passy, 1900 feet; and of Rochefort, 2765 feet. The discovery of such sources of supply in the comparatively waterless districts of Australia, where immense herds of cattle and sheep are grazed, has proved of inestimable value, since, under former conditions during periods of prolonged drought, millions of these animals perished for lack of water. Of 454 bores which have been made, 317 overflow, and the total daily outflow of water amounts to over 193 millions of gallons daily. Some of these bores are as deep as 4000 feet; more common depths, however, are 1600, 1700 and 1800 feet respectively. Owing to the depth of Artesian wells, their water is high in temperature; that of Grenelle is 82° F., that of Rochefort, 106° F., and in some of the Australian wells it is as high as 180° F. They provide large quantities of water; that of Grenelle, for example, gives 500,000 gallons daily, and this well obtains its supply from an area 100 miles from Paris; in the Australian bores, the daily output varies in different wells, in some 700,000, in others 1,500,000 and 3,000,000 gallons daily.

The Artesian water-supply of Australia is interesting from a geographical and geological point of view. It appears that on this continent a central sea existed in mesozoic times which became filled by sediments in cretaceous times. These strata became uplifted in the Tertiary period and ultimately formed with palæozoic rocks a united continent. Further depression caused submergence of the coastal and central land, which depressions, still later, were followed by a re-elevation. The one great river-system of the continent, the Darling-Murray, which never runs dry, is limited to one section only of the country. The other rivers are of comparatively short course, and empty into the ocean at different parts of the coast. Interior rivers and creeks quickly run dry during droughts, their water disappearing by evaporation and rapid percolation into the soil. The rocks which hold the Artesian water form a part of the cretaceous formation, and are composed for the most part of open, porous sandstone quickly absorbing and freely giving up water. In Queensland they have been proved to 700 feet of vertical depth, but are believed to be of even greater depth. They lie at depths below the surface varying from outcrop level to over 5000 feet, and are freely developed in Southern and Western Australia, Queensland, and New South Wales; and in Queensland lie under nearly two-thirds of the total area of that State, or over 445,332 square miles. According to Dr Jack's special surveys, the rock outcrop or water-intake areas have a combined length of over 1000 miles with a minimum width of 5 miles. In the northern part of the State there is a continuous outcrop of 280 miles in length and a minimum width of 90 miles.

These outcrops are situated in declivities of rising ground above the plains of the interior; so that the geological conditions of Artesian water are fulfilled. The mean annual rainfall over the intake areas is about 26 inches. The Artesian rocks, with the whole cretaceous formation, after great geological upheavals and depressions, have assumed an undulating curvilinear form from their outcrop on the land to their termination in the bed of the ocean. This has been proved by borings to Artesian water along a line of country of over 1000 miles in length, in which, the country being fairly level, the depth to the water varies from 200 to over 5000 feet. Pittman, the Government geologist of New South Wales, is of opinion that the Triassic or Jurassic strata may lie under the cretaceous formation, and the porous character of the formation may form the chief storage-beds of the Artesian water in the States of Nebraska, Texas, and Kansas in the United States of America. According to the last Government report of the Water-Supply Department of Queensland, the total number of Artesian bores in that State, including sub-Artesian or non-flowing wells, is 891, of which 6 per cent. only were made by the State, the average depth of bore being 1197 feet. The total continuous yield from 532 bores, known or calculated, is 351 millions of gallons per day. Sixty of these bores deliver over 1½ million gallons each daily, and of these one delivers 4½ million gallons daily, and another 6 million gallons daily.[1] Artesian water is being used for irrigation purposes.

The water from Artesian wells, although pure from the bacteriological point of view, not unusually contains relatively large amounts of total solids. In some of the Queensland wells, for example, the water has been found so brackish that animals will not drink it. This fact helps to prove the view that some of the Artesian water, at least, is derived from the ocean.

This is a risk to which water obtained from wells and headings near the sea are liable. Willoughby gives an account of an instance in which, owing to the infiltration of certain salts into the water-supply of a borough in England near the sea which was obtained from a well, the source of supply had to be abandoned. This well was over half-a-mile from the sea and was sunk originally in the upper greensand, various additions in the form of headings and borings having been made from time to time. These headings were below the tide level at high water. The supply from this source was sufficient to yield a 20–30 gallon per head supply to about 40,000 of population of the borough. The water gave a chlorine figure of 3 to 5 grains per gallon, and of 18 degrees of hardness. In 1892, it began to be noticed that the water had become perceptibly harder, and by 1895 the hardness was so much marked that constant complaints were made. Examination of the water showed a very marked increase in amount of inorganic solids, and also of chlorine. For example, in June 1891 the hardness was 23° and the chlorine 5·4 grains per gallon, in October 1895, the hardness had become 124°, and the chlorine 112 grains per gallon, and in September 1896, the chlorine reached its maximum—viz. 148 grains per gallon, the hardness having fallen to 83·5°, the total solids being 262 parts per 100,000.

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[1] Jack, "Geological Survey," Queensland, Bulletin No. 1, 1895; *Geograph. Jour.*, 1902, vol. xix., No. 5, p. 560.

In driving wells, natural gas is sometimes met with. It was discovered, for example, in 1836 during the sinking of a well at Hawkhurst, West Sussex, again at Netherfield on the South Eastern Railway in 1873–1875 in the sub-Wealden boring, and again in sinking a well at Heathfield, Sussex, 1895, and again at a depth of 300 feet in a shaft sunk for water at the railway-station there. The gas was used for lighting the railway-station. In that neighbourhood, in each of six wells sunk since 1895, gas had been found, and it was being employed to drive gas-engines, etc., and for lighting purposes. The gas was found to have the following chemical composition—viz.

Carbon monoxide	1·00
Methane	93·16
Ethane	2·94
Nitrogen or other inert gas (by difference)	2·90
	100·00

At Medicine Hat, Canada, sufficient natural gas is obtained from borings to an amount more than sufficient to light the place.

Many towns in England derive some of or even their chief supplies from Artesian wells. Among these may be named Canterbury, Cambridge, Bury St. Edmunds, Deal, Coventry, Leamington, Southport, Bedford, Scarborough, Hatfield; and at Uxbridge, Berkhampstead, Chesham, and other places, they have been sunk for supplies for watercress growing, while in places where a suitable hard water for brewing purposes is not obtainable, bores have been sunk by brewers to obtain such supplies.

From Rainfall directly.—In rural districts, where other sources of supply are either not available or are too costly to utilise, the rainfall may be stored, under certain conditions, for potable purposes. In hard-water districts it is stored for washing purposes. Besides, there are certain places, as Aden, in which the sole source of supply is the rainfall, which is collected in reservoirs in the rocky reaches above the town. But the rainfall cannot be used in populous and manufacturing centres because of the impurity of the air. The gathering-ground of the rainfall for an individual house is the roof. But since that surface is apt to be polluted in various ways, by bird-droppings and dust for example, all the rain which falls cannot be used. It is advisable that the first part of a rainfall should be rejected. To meet these conditions, an ingenious arrangement called Roberts' Separator has been devised. It is constructed in sizes which bear a certain ratio to the superficies of the roof-area, and is so arranged that when a sufficient amount of rain has fallen to cleanse the roof, the water first collected is tilted into a waste channel, and the after-fall is directed into the collecting channel and reservoir. It is always better that the rainwater, even when so collected, should be subjected to filtration, which is easily accomplished by underground filters.

The same inventor has devised a roof-washings tank, whereby pure water may be obtained from the roofs of cottages and houses too small for the use of the separator. This tank is intended to catch the dirty water which first comes from the roof during a spell of rain, and to direct the clean water that falls later into a storage tank, thus preventing any mixture of the unclean and clean water. The unclean washings from a roof vary from one to three gallons for every 100 square feet of roof-surface, depending upon the situation of the house relative to sources of aerial impurities. For rain-collecting purposes the only measurements required are the length and breadth of the ground covered by the roof, and the roof-eaves or gutters; thus the superficies in square feet is obtained. A slated or zinc roof of 300 square feet will be washed by a fall of 3–4 gallons, a tiled roof by 5 to 7 gallons, and a thatched roof by about 10–12 gallons. The inventor gives smaller amounts for slated and tiled roofs—viz. 3, and 4½–6 gallons respectively. The tank size is calculated on the basis that a roof of 300 square feet will be washed by a 3-gallon fall, and a tiled roof by a 4½–6-gallon fall, and the size of tank to be installed will, of course, depend on the superficies of any particular roof. For superficies of from 300 to 600 square feet of a slated or zinc-covered roof, and of 150 to 300 of a tile-covered or slate-covered roof in a town, a tank measuring 20 in. long, 7 in. broad, and 16 in. high will suffice, and for double these superficies, under corresponding circumstances, a tank measuring 24 in. × 7 in. × 21 in. A double cellar arrangement connected with the tank permits a maximum of 6 gallons to be collected in the tank before the rainfall is permitted to pass to the clean-water tank. The roof-washings tank must, of course, be periodically emptied, as required, by lifting the handle of the valve. These devices are likely to prove of considerable service in the case of isolated houses where any other source of supply is at a considerable distance, or is likely to be of a polluted character.

The quantity of water which may be collected annually from the roof of a house may be calculated by knowing the following data—viz. (*a*) the superficies of the horizontal area of the roof; (*b*) the average annual rainfall; (*c*) the average amount of evaporation. From the total calculated amount must be deducted from one-quarter to one-third for waste, evaporation, etc.

Example.—What amount of water might be collected annually from the roof of a house whose horizontal area measures 250 square feet, the annual rainfall being 27 inches ?

$$\begin{aligned}&250 \text{ feet} \times 2\tfrac{1}{4} \text{ feet} - \tfrac{1}{4} \text{ for waste}\\ &= 562{\cdot}5 \text{ cubic feet} - 140{\cdot}5 \text{ cubic feet}\\ &= 422 \text{ cubic feet} \times 6{\cdot}23\\ &= 2629 \text{ gallons.}\end{aligned}$$

The phenomenon of discoloured rain is not common although not unknown in this country. On 23rd Feb. 1903 the rain which fell in all counties south of the Thames, in Suffolk, and other parts of England, as well as in Westphalia, Germany, was found to be turbid and discoloured. When collected as it fell, it was found on analysis to yield 25·1 parts of total dissolved solids, 23·6 parts suspended solids, 2 parts of chlorine, 0·95 parts free and 0·15 albuminoid ammonia per 100,000. It was believed to be due to volcanic eruptions in the West Indies.[1]

Qualities of Water from Different Sources.—The Rivers Pollution

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[1] *Proc. Chemical Soc.*, vol. xix., No. 264.

Commissioners (Sixth Report) classified waters as to palatability and wholesomeness in the following way:—

Wholesome	Spring water	very palatable.
	Deep-well water	
	Upland surface-water	moderately palatable.
Suspicious	Stored rain-water	
	Water from cultivated land	palatable.
Dangerous	River water	
	Shallow-well water	

It is important to note that suspicious or even dangerous waters may be perfectly palatable, and may even present a bright, sparkling appearance, partly due to gases produced from the decomposition of contained organic matter and partly to the contaminated soil.

Water collected upon the surface of the oldest rocks, the metamorphic, granitic or quartzose, trap-rock, grey-slate, or greensand, is good, wholesome, palatable, and invaluable for potable purposes. Such waters contain but small quantities of dissolved mineral matter, and are therefore soft; having fallen through a pure atmosphere, they are well aerated; but they are usually tinged in colour with peaty products and vegetable organic matter. From the chemical point of view they contain little total solids, are free from suspended matter, contain little chlorine, little or no free ammonia, more than usual albuminoid ammonia, but no nitrates or nitrites, the oxygen consumed is small, and they possess but a few degrees of hardness.

Water from chalky limestone, magnesian, or ferruginous strata, though it is likely to be wholesome, palatable, and potable, possesses the disadvantage economically that it is hard, because of the carbonates of lime, magnesia, or iron which are dissolved in it. In water from the former two classes of strata, sulphates of lime and magnesia are likely to be present in addition to the carbonates, and may even form the chief cause of the hardness. Waters which contain the carbonate of iron are called chalybeate waters. With the exception of the mineral salts which they contain, such waters are usually pure, contain but little chlorine, free ammonia and albuminoid ammonia, and consume but little oxygen. It ought to be understood, however, that certain hard waters derived from rocks on the sea-board may contain what might at first sight appear to be excess of chlorine, and certain others from Artesian wells not only contain excess of chlorine and mineral solids, but also nitrates, due to the bore having reached strata of an old sea-bed, the waters otherwise being organically pure. Waters from the Wealden clay, London clay, and greensand share the same tendency to hardness, and the like characters as to purity. Waters which come from the coal-measures are apt to contain sulphur, either as sulphates or as H_2S, as well as iron. Water from gravel-beds is likely to be pure or impure according to proximity to filth-deposits.

The following table gives the views of the Rivers Pollution Commissioners on the relation of source of supply to hardness; the first-named being the softest, and the last-named the hardest:

Table XXXII

Table showing Relation of Hardness of Water to Source of Supply

a Rain-water (softest).
b Upland surface-water.
c Water from cultivated land.
d River water.
e Spring water.
f Deep-well water.
g Shallow-well water.

The only objection which may be offered to this table is that, in Scotland at least, shallow wells, except on the sea-board and in limited inland areas, usually contain soft water.

Source of Supply in Relation to possible Pollution.—The Table of the Commissioners already given indicates most accurately the relation of likely pollution to source of supply. About the time the Commissioners completed their inquiries, the bulk of the population obtained their water from contaminated sources; since, then, however, supplies have been improved. The only likely source of pollution of upland surface-supplies is from cultivated land, but this is practically never found in the supplies from the higher uplands. Part of the existing water-supply of Glasgow, for example, is obtained from the hilly ground to the south of the city. It was the main source of supply before the institution of the Loch Katrine scheme. The gathering-ground of this supply contains not a little cultivated land; and it may be taken as a type of the catchment-area of middle upland supplies. All supplies from such sources contain organic matter in questionable quantities, and therefore ought to be, as they mostly are, filtered. The water of rivers, except near their source, perhaps, is polluted more or less by animal organic matter, and, in may cases, cannot be safely used without constant and adequate filtration. Shallow-well supplies should *a priori* be considered as contaminated when in the vicinity of inhabited houses, until proved to be otherwise.

Hardness and Softness.—These are terms which are employed to express the difficulty or ease with which water unites with soap to form a lather; in other words, the soap-destroying power of a water. Economically, this is of importance in a manufacturing community and for domestic uses. Every degree of hardness in a water destroys 1½ lbs. of soap per 1000 gallons; hence a water of 10° and 20° of hardness will require 15 lbs. and 30 lbs. of soap respectively per 1000 gallons. Owing to the installation of the Loch Katrine supply into Glasgow, the annual monetary saving in soap alone by the use of this soft water has not been less than £36,000, not to speak of the lessened expenditure of coal for steam-raising purposes by the absence of "fur" in boilers. The hardness of the London supplies compels an annual expenditure in soap alone of about £250,000. Waters differ much as to hardness or softness; that of Glasgow, for example, having only about 1° to 1½°, those of London from 12° to 21°, and that of Sunderland 30°. The table already given indicates, generally, the relation of source to hardness or softness. Hardness is due to the presence of salts of lime and magnesia, alumina and iron, of chlorides, carbonates, and sulphates of the two first, and of the carbonate of iron. The carbonates are formed from solution of limestone, magnesian limestone, and ferruginous strata by the CO_2 dissolved by the rain as it percolates into the earth's crust. The rationale of soap-destruction is as follows :—Hard soap is a compound of various fatty acids with soda ; it is, therefore, chiefly composed of the stearate, oleate, and palmitate of soda. On being melted in a water containing lime and magnesian salts in solution, they decompose the soap and unite with the oleic, stearic, and palmitic acids to form these salts of lime, which, however, being insoluble in water, float like curdy flakes on its surface. So long as lime or magnesia is present ununited with these fatty acids, no lather will form ; but when excess of soap is added, lathering takes place. Hardness is distinguished as existing in waters in one or other or both of the following forms—viz. *removable* or *temporary*, and *irremovable* or *permanent*. Removable or temporary hardness is so designated because it may be removed by boiling, and the other form as irremovable or permanent, because it cannot be so removed. As has been said, the carbonates of lime and magnesia exist in solution by excess of CO_2 —indeed, they may be presumed to be in the form of bicarbonates —and when the water is boiled and the excess of CO_2 is thus driven off, the calcium and other carbonates are thrown out of solution, and become visible as a milky sediment, according to the following equation :—

$$CaOCO_2CO_2 = CO_2 + CaCO_3.$$

This calcium carbonate, along with any magnesium carbonate present, is, therefore, liable to become deposited on the interior surface of boiling vessels, as hot-water boilers, kettles, hot-water pipes, etc., as a " fur " or " scale." This deposit, in turn, compels the increased use of fuel to generate steam, or the institution of measures to prevent furring, it corrodes the boiler-plates, and gives rise to boiler-explosions from the consequent thinning of the plates. Any hardness which remains after boiling is called permanent hardness. The sum of both *temporary* and *permanent* hardness constitutes *total* hardness. It is not impossible, however, even to reduce the so-called permanent hardness by chemical means. By addition of carbonate of soda, double decomposition takes place with the formation of sodium sulphate and carbonate of lime, the latter being precipitated in the boiling. This process is used in the Desrumaux system of water-softening.

Effects of Impure Water on Health.—Impurities in water which are apt to affect health are divisible into two classes—viz. (A) those which have their source in filth or sewage contamination ; (B) those of the nature of mineral or other constituents. The second class is, probably, of lesser vital importance than the first.

(A) From the impurities falling under the first head may arise cholera, enteric fever, diarrhœal diseases, and dysentery. The sewage-polluted and unfiltered water of the Elbe, in 1892–1893, caused a very widespread and fatal epidemic of cholera in Hamburg and Altona. Hamburg, with a population of 640,400, had 16,907 cases, or 264·8 per 10,000, with 8606 deaths, while the coterminous town of Altona, with 148,600 of population, using the same water-supply but filtered through sand, had only 516 cases, or 34·6 per 10,000, with 316 deaths. The origin of outbreaks of enteric fever in polluted water-supplies has been proved in all civilised countries. The following table[1] indicates some of the principal epidemics of this and other countries from water-supplies.

TABLE XXXIII

TABLE OF EPIDEMICS FROM POLLUTED WATER

Year	Place	Disease	Population	Cases	Deaths
1867	Guildford . . .	Enteric Fever	. .	250	. .
1867	Terling, Essex . .	,,	900	260	. .
1872	Lausen (Switzerland) .	,,	780	130	. .
1874	Over-Darwen . . .	,,	22,000	2,035	104
1878	Caterham . . .	,,	. .	179	. .
1882	Bangor, North Wales .	,,	10,000	540	. .
1882	Wittemberg Barracks .	,,	386	66	. .
1885	Plymouth, Pennsylvania ..	,,	9,000	1,000	. .
1887	Mountain Ash, Wales .	,,	. .	over 500	. .
1889	New Herrington, Durham	,,	3,600	278	. .
1890-91	Tees Valley . . .	,,	. .	1,463	. .
1892-93	Hamburg . . .	Cholera	640,400	16,957	8,606
1893	Worthing . . .	Enteric Fever	15,000	1,261	
1893	Paisley	,,	. .	over 800	. .
1896	Dunbar	,,	. .	. .	. .
1897	Maidstone, Kent . .	,,	. .	1,786	. .
1897-98	Philadelphia . . .	,,	. .	1,927	. .
1898	Paisley	,,	. .	279	34
1905	Lincoln	,,	51,000	996	. .

Note.—(...) signifies that the number is not noted.

The pollution may arise in the gathering-ground or reservoir, as in the Maidstone, Plymouth (Pa.), Dunbar, and Paisley epidemics; from wells, as at Guildford in 1867, New Herrington (Durham), in 1889, and at Morningside (Edinburgh), in 1894. In the New Herrington case, it was shown that the pollution of the deep well had its origin in the sewage of a farm three-quarters of a mile away, and in that of Edinburgh, from sewage in a quarry 800 feet distant from the well. In the Wittemberg Barracks epidemic of 1882, the cause was leakage of enteric sewage through the cracked cemented walls of the well, and in that of Caterham, in 1867, to a workman employed at the water-works who was suffering from enteric fever of a slight degree, defæcating in a shaft leading to the water conduit. The epidemic of Lausen, Switzerland, in 1872, was due to contamination of a spring by the sewage of a farmhouse, some distance away, finding its way by a subterranean channel. River-supplies are also constantly liable to pollution, and give rise to enteric fever epidemics. Those of Bangor (N. Wales), in 1882, of the Tees Valley in 1890–1891, of Philadelphia in 1897–1898, and others, are cases in point. Not only may pollution occur at the source, but it may arise, also, in the distributory channels. The epidemics of Over-Darwen in 1874, of Mountain Ash (Glamorgan), in 1887, and of Paisley in 1898, may be cited as examples.

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[1] Paper by the Author, "The Supervisory Control of Water-Supplies" (*Sanitary Journal*, 1900).

The largest epidemics within recent years of water-borne enteric fever in England were, perhaps, those of Worthing in 1893, Maidstone in 1897, and Lincoln in 1905. A few comparative facts from each of these will prove instructive. The population of Worthing at the year of outbreak was a little over 15,000 persons. While the outbreak may in one sense be said to have existed from May till December, it consisted in reality of two distinct outbursts—viz. the first lasting from 3rd May till 1st July, and the second, from July till December. In the first outbreak the total cases numbered 303, and in the second, 958; being in all 1261 cases within the year 1893. In the latter outburst, the number attacked in the first three weeks was 557; in the second three weeks, 214; in the third, 100; in the fourth, 46; in the fifth, 20; in the sixth, 11; in the last three weeks, 6; four more cases occurring during December. In the Maidstone outbreak, which lasted from September 1897 till January 1898, the total number of cases was 1786. The population of the town at the time was 33,830. The number of cases in the first three weeks was 1201; in the second three weeks, 423; in the third, 100; in the fourth, 46, in the fifth, 11; and in the last three weeks, 3; there being two more cases from 4th September to 11th September, just prior to the acute outburst.

In the Lincoln epidemic, which lasted from 22nd January till 21st June 1905, there were in all 996 cases. The population of the city at the time was 51,000. The number of cases in the first three weeks was 547; in the second three weeks, 200; in the third, 125; in the fourth, 87; in the fifth, 28; in the sixth, 6; and in the last three weeks, 3 cases.

Reece[1] in his Report to the Local Government Board concerning the Lincoln epidemic stated that the outbreak had its origin in specific pollution of the public water-supply, and Klein reported that he had found an organism in the water of an inlet or feeder to the waterworks which resembled *B. typhosus*, and which gave positive results to the morphological, chemical, and biological tests by which that micro-organism is differentiated.

It will be observed that in each of these populous places the water-supply was typical of a supply which was liable to specific pollution. That of Worthing was from deep wells in the chalk close to fissures which were in direct communication with defective drains and sewers; that of Maidstone, from numerous springs several of which were open to pollution, and which, moreover, were outside of the official control of the medical officer of health of that borough; and that of Lincoln derived from streams which were constantly polluted by excreta, human and bestial. In each case, also, was the infection co-extensive with the distribution of the water-supply, the outburst was explosive in character, and was subsequently characterised by rapid decline in numbers, and, later, by gradual decrease of cases.[2]

In 1906, 26 cases of enteric fever were reported in the Panteg Urban District of Monmouthshire by the medical officer of health. It was believed they were due to specific pollution of the water-supply. It was stated that, owing to shortage of water, the water-company had passed water of questionable purity into their supply.[1]

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[1] Report to Local Gov. Board, 1906.

[2] *B. M. J.*, vol. ii., 1905, p. 1463.

A serious epidemic broke out in the Rhondda Urban District in 1904–1905. There are two water-supplies within the areas affected, one belonging to the Rhondda Urban District Council, and the other to the Pontypridd Water Company. From 1st November 1904 to 10th February 1905, 399 cases in all were notified. The medical officer of health in his report was of opinion that no one factor or combination of factors could account satisfactorily for the nature of the outbreak. Bacteriological examinations of water-samples proved them to contain a high percentage of coli-like organisms, and even the filtered water to be unsatisfactory from the bacteriological point of view. The mortality-rate from enteric fever in that district during the past ten years has been slightly more than twice the rate for England and Wales.

Short of enteric fever, outbreaks of an anomalous character have occurred from time to time in different places. In Hull, some years ago, about 20,000 of the inhabitants were attacked with diarrhœal disorders by reason of ditch-water finding its way into the supply-reservoir.

Liability for Supplying Impure Water.—There have been from time to time within recent years actions of damages before the English law-courts against water-purveyors. Of these, we record briefly the facts of two cases.

I. Fergusson and the Malvern District Council.

Before Mr Justice Lawrence, a special jury awarded the plaintiff, a medical man, £7000 damages and costs, because the defendants—the local water-authority—had permitted sewage to contaminate the water used in his hydropathic establishment, whereby a number of cases of enteric fever resulted among the residents in that establishment, to whom the plaintiff had had to pay heavy compensation.

The defendants appealed, and at the hearing in the Appeal Court it was argued on their behalf that, on the findings of the jury, Mr Justice Lawrence ought to have entered judgment for the defendants. The peccant water came from a well from which it flowed into plaintiff's tanks. The questions left to the jury to determine were: (1) Whether plaintiff had any proprietary right in that water; and (2) Had the plaintiff any licence to use the water from the owners, the defendants? The jury answered both questions in the negative. For the plaintiff it was argued that the defendants were rightly held responsible, because the water in the well had been polluted by percolage of sewage which could have been prevented by defendants.

The Appeal Court held unanimously: That the defendants were entitled to judgment on the ground that a man who took without licence water belonging to another had no right of action against that other, even if it were contaminated by sewage or rendered unfit for domestic purposes from any cause whatever.[2]

II. In the King's Bench Division on 27th March 1908 an action was raised by the widow of a farm-bailiff of The Three Counties Asylum, Bedfordshire, against the authorities of that institution for having brought about the death of her husband by negligently supplying the cottage in which he lived with impure water. The water-supply of the cottage was from two wells, the water therefrom being passed through a water-softening apparatus, and thence into a water-tower for distribution to the asylum and its outlying official houses. It was argued on behalf of the plaintiff that there was communication between these wells and the sewage drains of the asylum, that the water was habitually unfit for use, that complaints had been made regarding its unfitness, and that the plaintiff's husband had died from enteric fever contracted in using it. The argument for defendants was that deceased must have contracted the disease while on holiday, that the colon bacilli which were found in the water, upon which the evidence of sewage contamination was founded, were conveyed to the water by rats and not by sewage, and that, had the illness of defendant been due to the use of the asylum water, there must have been an outbreak of enteric fever among the inmates of the asylum, whereas at the time deceased was ill there was no such outbreak. The defendants had to admit, however, that a month after the illness and death of plaintiff's husband some fifteen or sixteen of the asylum inmates were stricken with enteric fever. The jury found for plaintiff and awarded £650 damages.

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[1] *B. M. J.*, vol. ii., 1906, p. 804: also *ibid.*, vol. i., 1908, p. 1132: and p. 1147.

[2] *B. M. J.*, vol. i., 1908, p. 1147.

Dysentery is endemic in Egypt, in South Africa, and in other parts of the world from polluted water. Certain parasitic diseases, too, which affect man, are also traceable to water which contains the ova of certain parasites, or their mature forms. The Mount Gothard outbreak, due to the *Ankylostomum duodenale*, is an instance. In like manner, it is believed, may *Tænia solium*, *Tænia echinococcus*, and other tapeworms, *Ascaris lumbricoides*, *Oxyuris vermicularis*, *Filaria perstans*, *Bilharzia hæmatobia*, *Filaria dracunculus*, and other parasites find a nidus in the human body. There is also good reason to believe that such microbic diseases as anthrax and glanders have been propagated among animals from the water of public drinking-troughs, by specific contamination from infective cattle or horses.

(B) *From Mineral or other Constituents.*—The mineral constituents of water, when abundant, are apt to engender not only discomfort but disease. Persons who for nine or ten months of the year use soft water for potable purposes and food-preparation, are very liable at first to gastro-intestinal disturbance when they remove for a summer holiday to a district where the water is hard. This is particularly true of those with a rheumatic or gouty diathesis. Constipation alternating with diarrhœa, or continuous diarrhœa, with gastric catarrh and dyspepsia, are common effects, until acclimatisation is established. Certain definite diseases have been for ages attributed to the constant use of hard water. Goître, or "Derbyshire neck," and cretinism are the chief. By some observers these affections are declared to be due to the sulphates of lime and magnesia in the water, and by others, to certain metallic sulphides, notably that of iron. In Switzerland, the Himalayas, Cochin China, and the Pyrenees, as well as at home, cretinism, which consists of a rickety condition of the osseous system, associated with imperfect development of the brain indicated by imbecility, is by no means uncommon. Norris, about half a century ago, described the endemic cretins of the village of Chiselborough in

Somerset. This village lies in a valley hemmed in on all sides but one by hills over 400 feet high. Its population numbered 540; of these two to three hundred were goîtrous, of low intelligence and defective speech, 20 were cretins, and 5 goîtrous deaf-mutes. All these have now practically disappeared under improved sanitary conditions. As to the origin of the affections, much striking evidence has been adduced. McClelland, quoted by Hirsch,[1] says of the province of Kuman in the Himalayas, that in 91 villages situated on granite and gneiss, hornblende-slate and mica-slate, green sandstone, grassitine, and silicious sandstone, with a total population of 5383, there were 29 goîtrous persons and no cretins, but that in 35 villages on Alpine limestone, with a population of 1163, there were 390 cases of goître and 34 of cretinism. A French Commission appointed to make investigation on this subject, obtained some remarkable evidence, as, for example, the following: In 1848, in a town called Bozel (Tarentaise), of a population of 1472 persons, 900 had goître and 109 were cretins, while the village of St Bon, situated about 1100 yards higher than Bozel, was free from both diseases. Each had its own separate water-supply, that of Bozel was a hard water containing magnesium and lime sulphate, and that of St Bon was a soft water. A pipe was laid from St Bon to Bozel conveying this soft supply. Sixteen years later—1864—in Bozel, the number of goîtrous persons had fallen to 39, and of cretins to 58. Against this, however, must be placed the contrary experience of such places as Sunderland, where the water is of 30° hardness, principally due to sulphates of lime and magnesia. While, therefore, the causal relationship of hard water and goître appears to be so close, it has not yet been clearly determined that lime and magnesium salts alone are the causative factors. In 1898, Grasset of Montpellier communicated to the French Academy of Sciences the results of investigations, extending over ten years, on persons suffering from goître in the Puy-de-Dôme department of France. In the blood of eight persons suffering from recently acquired goître—from ten to fifteen days—Grasset found special hæmatozoa. He describes them as spherical bodies larger than a red blood-corpuscle, non-nucleated, containing red pigment, and possessing a free flagellum. Although they resembled the hæmatozoa described by Danilewski, Grasset avers that none of the patients were malarious. From the existence of this hæmatozoon, Grasset believes goître to be infectious. These observations, it must be added, have not yet been sufficiently confirmed to enable it to be definitely affirmed that the disease is due to a hæmatozoon.

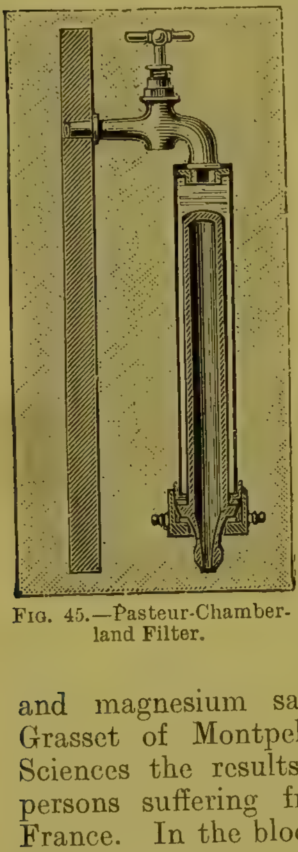

Fig. 45.—Pasteur-Chamberland Filter.

Probably among the most recent researches on this subject are those of McCarrison regarding the prevalence of the disease in the

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[1] "Handbook of Geographical and Historical Pathology," vol. ii., p. 175 (Syd. Soc. Ed.).

Chitral and Gilgit valleys of India. In these districts goître prevails extensively. From his observations, carried on over three years in these districts, he arrived at the following conclusions :—(*a*) that the water-supply, which was from limestone rocks, was the vehicle of spread of the disease; (*b*) that at the source of supply it produced 11·8 per cent. of cases; (*c*) that at the point of distribution it caused 45·6 per cent. of cases; and (*d*) that between the source and the terminus of supply, therefore, some goître-producing element, organic or inorganic, must have been introduced into the water. He draws attention, further, to the following points :—(1) that water, if it is the chief vehicle of infection, is not the only vehicle; (2) that the disease is not due to any dissolved ingredient in the water; (3) that experiments on dogs in Gilgit were constantly negative; (4) that the increased prevalence of goître in the population in the lower parts of the Gilgit supply was due to the increased impurity of the water lower down; (5) that the people of Barmis, although living in the Gilgit fan, do not suffer from the disease; (6) that the disease is constantly associated with limestone rocks in Chitral and Gilgit; (7) that the disease can be rapidly acquired by susceptible individuals in goîtrous districts after a residence of from three to four weeks; and (8) that there are grounds for the belief that indigenous inhabitants of goîtrous districts acquire through several generations a natural immunity to the disease.

The analysis of Gilgit river water is as follows :—

		Grains per gallon.
Total solids	=	7
Total hardness	=	4
Calcium	=	about 6
Magnesium	=	not found
Iron	=	trace
Sulphates	=	3
Chlorides	=	small
Free ammonia Organic Matter Nitrites Metals (other than above)	=	nil

In the goîtrous districts of this region no animal examined—including dogs, mules, cows, sheep, goats, and ponies—was found to be goîtrous. In discussing the question of water being causative of the disease, this writer asks the question: Can the water of the Gilgit river at its source—the pure water from the melting snows of the hills—take up on its way down a rocky nullah or ravine such ingredients as will give rise to goître among the people who drink it in the valleys lower down? He points out that the people of Nagar have begun to be affected with the disease during the past six years only, the water-supply having always been the same; that goître was introduced from without; and that it commenced in infants under one year. He feels compelled to admit that the water in the whole district is the vehicle of the disease, but he believes that three factors have to be considered as in some way causally connected with it—viz. (*a*) geological origin of the soil, (*b*) dampness of soil, and (*c*) slope of the ground. Although in Chitral and Gilgit, taken generally, the disease is invariably associated with limestone rock formations, he has observed that most goîtrous persons are found in villages situated on damp soil.

He has made examinations of the blood of over a hundred cases of the disease, but he has never met with Grasset's hæmatozoon. In the fresh fæces of goîtrous persons, however, he has found two varieties of organisms: one spherical in form, and the other pear-shaped or ovoid, sometimes accompanied by appearances microscopically resembling a shell or chitinous envelope. He believes the organism to be a sporozoon. By the internal administration of thymol as an intestinal disinfectant or antiseptic, a marked reduction in size of the thyroid enlargement has been observed to result. He has reached the conclusion from his observations that goître is caused by an organism which, living in the soil of infected localities, invades the body through the medium of the water-supply.[1] Nearer home observations are also being made. Spurway[2] gives some facts relating to the prevalence of this disease in Hertfordshire and Buckinghamshire. The cases were equally found in a population occupying a tableland of the Chiltern Hills about 700 to 800 feet above sea-level, and in a valley about 400 feet lower. Part of the district is on chalk with a large admixture of flints, and part on clay. There is no running water. Sixty cases were found here. The disease was found to prevail among those very closely intermarried, and among the cases were several of low intellect, who constituted the village "naturals." The water-supply of these goîtrous persons was obtained from various sources; some from ponds, some from wells in chalk or clay; and some from collected rain-water. The districts are now supplied with water from the chalk formation by the Chiltern Hills Water Company.

From the gradually accumulating material of observation, it would appear as if the indications more and more strongly pointed to a sporozooic or hæmatozooic cause of this disease.

Purification of Water on the small scale: (1) *Boiling.*—Those impurities in water due to sewage contamination which are most dangerous to health and life may be got rid of, on the small scale, by boiling and by filtration. Since, however, boiled water loses its piquancy of flavour, due to the atmospheric gases which it contains having been driven off, it is necessary to re-aerate it to make it palatable. This may be done in a variety of ways, as by pouring it from one vessel to another, preferably through a rose-opening, or a sieve. *Household filters* are the means adopted to purify water from suspended matter. Much has been written in condemnation of these filters, but their failure seems to consist in their inability to arrest micro-organisms, and also that the filtering media are not cleansed sufficiently often. But provided that the media are re-purified at regular short intervals, their action is not only safe, but fairly efficient as regards suspended matters. The filtering media in most common use are: (1) carbon, animal or vegetable, in powder or in block, and alone, or combined with manganese, silica, or iron; (2) sand, solid or in grains; (3) iron, in some form, as spongy iron, polarite, magnetic carbide of iron, and iron combined with charcoal and clay, called carferal; (4) asbestos, as in Maignen's *Filtre rapide.* To purify the carbon and asbestos, it is only necessary to heat them to a red-heat, and the others, by washing several times with boiling water. The only filters which do not permit the passage of microbes are the Pasteur-Chamberland and Berkefeldt, the former of which consists of a bougie or hollow candle of unglazed, or "*biscuit*" porcelain, and the latter of tubes of compressed diatomaceous earth. These bougies are enclosed in a metal case, which may be screwed on a water-tap, or be connected with a small tank. Even these require frequent and careful cleansing, because of their ability to arrest the finest suspended matter; and this is best accomplished by subjecting the bougies to a red-heat, after preliminary washing and brushing.

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[1] *Lancet*, vol. ii., 1906, p. 1570; *B. M. J.*, vol. i., 1906, p. 861.

[2] *B. M. J.*, vol. i., 1906, p. 1037.

Bulloch and Craw[1] have submitted to rigid tests a cheap white porcelain filter supplied by Doulton & Co., and their experiments proved that, like the Pasteur-Chamberland bougie, it prevented the direct transmission of contaminated water at low pressure, and the direct transmission of organisms by filtration with the vacuum pump, thus proving its value for obtaining sterile filtrates for laboratory uses. The thickness of the wall of the Doulton, compared with the Pasteur-Chamberland bougie, is in the ratio of 1 : 1·35, thus probably accounting for the greater rapidity in filtration of the former compared with the latter, which stands in the average ratio of 1·57 : 1. Microscopic investigation of the substance of the Doulton bougie showed remarkable homogeneity.

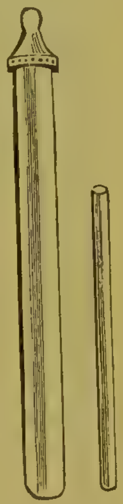
FIG. 46.—Bougies for Pasteur-Chamberland Filter.

(2) *Distillation* is the method commonly employed on board steamships. Distilled like boiled water has a flat taste, and, therefore, must be re-aerated to restore its flavour. It is free from organisms and dissolved solids.

(3) *By Addition of Chemical Substances.*—These have been tried mainly with armies in the field to overcome the delay consequent upon boiling or sterilising the water-supplies. In the Soudan, our army used a form of bromine process, the French have tried potassium permanganate, alum, and chalk, the Belgians an apparatus for generating hydrogen peroxide, the Austrians, calcium hypochlorite; but all have been found ineffective. Parkes and Rideal[2] have experimented with a great variety of chemical agents to produce sterilisation of water, and of these probably the most efficient and most active were tartaric acid and acid sodium bisulphate. The latter salt, it is stated, destroys the *B. typhosus* after five minutes' contact in a solution containing 15½ grains to the pint of infected water—*i.e.* one part of the salt to about 565 parts of water. It has been found better, however, to permit of fifteen minutes' contact. It is believed, moreover, that if men on the march were supplied with the salt in the form of 5-grain tabloids, thirst would be lessened and the immediate hunger for water stayed until efficient sterilisation of supplies by certain methods could be achieved.

Purification of water on the large scale is effected by sedimentation and filtration; and these are necessary in all waters derived from catchment-areas containing arable land, and from rivers. Sedimentation is allowed to take place during the period of stay in a large reservoir, and the action of gravity causes suspended matter, coarse and fine, to fall, and in doing so to entangle in it micro-organisms. In the term sedimentation must be included the effects of sunlight, for the diminution in number of micro-organisms per c.c. which follows sedimentation must be partly attributed to the operation of both causes. In the case of the London companies, the average number of microbes is reduced from 16,000 per cubic centimetre to numbers varying from 1000 to 7800. It has been clearly demonstrated from the experiments of Delépine and others, (1) that sedimentation is an important factor in the bacterial purification of water, and (2) that the best results appear to be obtained when the flow of water in a reservoir is sufficient to prevent stagnation, and, at the same time, to enable gravity to operate. In large waterworks, sedimentation is achieved by abundant area of storage-reservoirs. But *filtration* must be deemed as the most important factor in purification. While the filter-beds may be constructed of different total depths of filtering-media, and the constitution of the filter-bed differs in different cases, it may be said that a filter-bed is composed, from above downwards, of (1) a layer of sharp sand, (2) gravel or broken shells, and (3) small boulders or large gravel. It would appear, however, from experiments of many observers, that the efficiency of filtration does not depend so much upon the total depth or composition of the filter-bed, as upon the rate of filtration and the formation of a gelatinous scum on the surface of the filter-bed. In London, where filtration is carried on on the largest scale, the depth of the water on the filter-bed is never greater than two feet, and from this the average rate of filtration per square foot is 42 gallons per twenty-four hours. One hundred acres of filter-beds are employed by eight London companies, and the efficiency of filtration may be gathered from the fact that the number of organisms per c.c. is reduced from 16,000 to numbers varying between 35 and 100; and according to Frankland, the number of micro-organisms in unfiltered Thames water at Hampton is reduced by over 97 per cent., on the average, by sedimentation and filtration. The experiments of the Massachusetts Board of Health clearly prove that, under the following conditions, filtration would remove fully 99 per cent. of organisms—viz. (*a*) a filter-bed of sand of 60 inches in depth, the average size of sand grain being ·09 millimetre; (*b*) a rate of filtration of two million gallons per acre per day. Koch, indeed, has laid down the principle that no water should be permitted to enter a service-reservoir which contains more than 100 organisms per c.c. The highest point of efficiency of a filter-bed is not attained, as might *a priori* be expected, immediately after it has been set in operation, or has been renewed, but until some days—five to ten or more—after it has been working. This points to the fact that water-filtration is not merely a mechanical straining operation, but is something more. When the surface of a filter-bed is examined after about twelve days' work, a thin gelatinous layer, or film, will be found to have formed. This seems to be a biological filter, in which the micro-organisms are arrested. Upon examination, this film or scum is found to consist of organic matter and bacteria. The life of a filter-bed for efficient action will depend upon the character of the water to be filtered, but in the cases under consideration it lasts for from three to six weeks or longer. At the end of this time, the filter-bed is allowed to run dry, and the top inches of sand are removed, and washed rid of organic débris in a washing-machine, while they are replaced by clean sand.

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[1] *Jour. of Hyg.*, vol. vii., p. 408.

[2] *B. M. J.*, vol. i., 1901, p. 242.

Part of the Glasgow area of water-supply is still provided from the Gorbals waterworks, which was the main supply before the institution of the Loch Katrine supply. This water is obtained from a gathering-ground near Mearns, some miles to the south-west of the city, and as a considerable part of it is on arable ground, the water after sedimentation in reservoirs is filtered before being sent to consumers. Each filter-bed is composed from above downwards of the following materials :—sharp Arran sand, 2 feet 6 inches, a layer of perforated glazed tiles and gravel, 6 inches, and broken stones (half-inch size), 2 feet ; making a total depth of 5 feet. The water-level on filter-bed is maintained at a height of one foot above the level of sand of bed. The rate of filtration is about 600 gallons per square yard of filter-bed per twenty-four hours. The filter-beds act in series ; one set being at work while the other is being cleaned and resting. The filter-bed is cleaned periodically by scraping off the top layer of sand to a depth of three-quarters of an inch or thereby, the removed sand being washed, a fresh clean layer of sand being substituted in its place.

For less extensive needs than for the population of a populous place, and for sterilising water for armies in the field and for gangs of navvies in engineering schemes, other methods of purification have been devised. One of these is the Lawrence Water Steriliser and Cooler. The apparatus has the advantages of simplicity, compactness, rapidity, and completeness of action, and ease and economy in working. The crude water enters the apparatus by a pipe which passes into the heating chamber, where it is heated steadily, continuously, and progressively, until it boils. Leaving this chamber it gradually cools, until, by the time it has reached the exit opening, it is practically of the same temperature as of entrance. A large plant has been installed at Leavesden Asylum under the Metropolitan Asylums Board which deals with 9000 gallons of water per hour. The bacteriological reports of the water treated in this installation after six months' working have been satisfactory. The system also softens waters so far as the hardness is of a temporary nature.

Of late years mechanical forms of filtration appear to be growing in favour, and especially in America, where at least 200 populous places have adopted the method. This is probably largely due to the fact that so many of these towns depend for their supplies upon river water which contains clay or other particulate matter in a very finely comminuted condition. Nearly all forms of mechanical filtration are based on the principle of mechanically adding some coagulant to the raw water and subsequently filtering the mixture at high velocity through sand, the filter-bed being periodically washed by reversing the current and blowing air through it. The Jewell filter consists of a steel cylinder, open at its upper end and closed at its lower end. Above the true bottom of the cylinder there is a false bottom on which is laid the filtering material composing the bed, which consists of a bottom layer of gravel and over it about forty inches of sand. About the middle of the cylinder containing the filter-bed begins an outer cylinder which extends to the top. This outer cylinder is a little wider than the inner, and thus leaves between an annular space, which is closed below, into which the raw water passes. Rising up in the annular space, it passes over the lip of the interior cylinder on to the surface of the filter-bed, and after passing through the bed reaches the exit-pipe purified. The coagulant, which has been added to the water prior to its reaching the filter-bed, consists of a 2 per cent. solution of sulphate of alumina, and is supplied to the raw water in a mixing tank. The water, now mixed with the alumina, passes into a subsidence tank, and thence into the filter as described above.

The use of sulphate of alumina results in the formation of a flaky, jelly-like substance, which carries with it to the bottom of the subsidence tank the great bulk of suspended matter. In Alexandria, Egypt, where the Jewell Filters are used, Bitter found that by using a six-hour period of subsidence 75 per cent. of micro-organisms were removed. Schreiber has reported favourably of the purification effected in an experimental installation of the Jewell Filters at the Berlin Waterworks near Lake Müggel.

The action of mechanical filters, used as described, is both a chemical and a mechanical action. If the water contains carbonate of lime, the chemical reaction which takes place with the sulphate of alumina is as in the following equation:—

$$Al_2(SO_4)_3 + 3CaCO_3 + 3H_2O = Al_2(OH)_6 + 3CO_2 + 3CaSO_4.$$

The hydrate of alumina formed, by reason of its physical characters, entangles within its flaky, jelly-like substance particulate matters of all kinds. Most of this subsides by gravity during its detention in the subsidence tank, and any which may still be in suspension is arrested in the surface and in the upper layers of the filter-bed, thus forming a scum not unlike in character to the biological scum formed in the slow-filtering processes, and, like the latter, arrests the progress of organisms as well as minute forms of plant life, or plankton, through the filter.

At Alexandria, Egypt, eighteen Jewell Filters are in use, each of these being 17 feet in diameter, giving 223 square feet of filtering surface, and 7 feet in height. The annular space referred to between the outer and inner cylinder is $5\frac{3}{8}$ inches in width, all round the filter. The works have to supply filtered water to about 400,000 persons, which varies between 4,500,000 and 8,500,000 gallons daily. From the bacteriological reports, the monthly averages of each separate filter varied between 9 and 27 organisms per c.c., the corresponding average numbers in the raw water being from 717 to about 4700.

Other mechanical filters are in the market and in use for water filtration, such as Bell's, Reeve's, Candy's, and others. The filters used for the Edinburgh water-supply are Bell's, the beds in the filter-chambers being composed of silver sand. There are twelve of these filters, and each filter is able to deal with from 6000 to 10,000 gallons per hour.

Another method of purification on the large scale, totally different in principle, moreover, from any already discussed, is by the use of iron in a revolving apparatus. The system has been installed at Antwerp and Boulogne-sur-Mer. Before the installation of this system at the Antwerp waterworks, the media employed for the filtration of the water were spongy iron and gravel, but they had to be abandoned owing to the fact that the filter-beds became gradually choked, and the iron almost inactive. Since 1885, the water of that city has been purified by the agency of Anderson's Revolving Purifier. The apparatus consists of a revolving cylinder into which is put a quantity of metallic iron in the form of cast-iron borings or clean scrap-iron, such as punchings from iron plates. The water to be purified is passed through this cylinder, the cylinder being made to revolve slowly, and thus the iron is kept in motion, being lifted up and showered down as the cylinder goes round, and mixed with the water as it slowly flows through the cylinder. The water takes up from one-tenth to one-fifth of a grain of iron per gallon. This is got rid of either by blowing air through the water or by causing the effluent water to flow along shallow open troughs; thus the oxide is thrown out of solution, and is allowed to deposit in sedimentation or subsidence reservoirs. The effect of the process is to rid the water of about 63 per cent. of organic matter, while micro-organisms are reduced in number, in the case of the Boulogne-sur-Mer water, from 800 to over 7000 per c.c. to an average of 40 per c.c.

In certain waters, derived from very boggy gathering-grounds, the colour is sometimes very pronounced, being not infrequently as high as sherry or pale beer. Experiments have proved that ordinary filtration reduces but little the colour, on account of the colouring matter being either in a dissolved or minutely-divided character. It is not unlikely that the methods of mechanical filtration just described may do more towards the reduction of this colour than any known system of open natural filtration.

Softening.—By reason of the economic and other disadvantages of hard waters, it has been found desirable to soften water on the large scale. For this purpose, several processes are in vogue; such as those of Clark, Porter-Clark, Howatson, Atkin, Desrumaux, the Stanhope, the Lawrence, and others. The original of these was Clark's, and was applied at the storage-grounds. The rationale of the process was to remove the hardness due to the carbonates of lime and magnesia, by adding freshly slaked lime in defined proportions, depending upon the hardness. The added lime, taking up the excess CO_2 which kept these salts in solution, forms fresh carbonate of lime and magnesia, throws the original salts out of solution, and the whole are precipitated together. The reaction which takes place for the lime is this: $CaOCO_2CO_2 + Ca(HO)_2 = 2CaCO_3 + H_2O$. The factors to be known for its practical application are these: (*a*) the cubic contents of, or quantity in gallons in the reservoir, the water of which is to be softened; (*b*) the number of degrees of temporary hardness of the water.

Clark's rule was that for every 100,000 gallons of water, 6 lbs. of freshly-burned lime for each degree of hardness were to be added; therefore, for waters of 10°, 15°, or 20° of hardness, the necessary quantities of lime would be 60, 90, or 120 lbs. respectively. The lime to be added being mixed in a tank with 500 to 1000 gallons of water, the bulk to be purified is made to pass slowly through it. The water thereupon assumes a milky hue, due to the carbonates in suspension which have been thrown out of solution, is then allowed to settle to permit of precipitation, the supernatant water is drawn off, and is re-aerated by passing it over an artificial weir composed of a rough surface. In the other processes, lime alone, or lime mixed with sodium carbonate, or with alumina in addition is used. But the great difference between Clark's original process and some of the other processes named is the mode by which the precipitated lime is got rid of. In the Porter-Clark process, the suspended lime and water are passed through filter-presses at high pressure. The same general arrangements are present in Atkin's system, but the deposit on the filter-sheets is rubbed off continuously as it is deposited by revolving brushes. In the others, more or less complicated machinery is employed. It may be said of them all that they very efficiently accomplish their object: and the effect is to reduce the hardness by several degrees, varying from 12 to 15.

In the Desrumaux process, which has been adopted in several places on the Continent, the object is not merely to rid the water of its temporary, but also, in some measure, of its permanent hardness. The water to be softened is run into a distributing receiver, one portion being diverted through a sluice-valve to fall on and propel a water-wheel by which the slaked lime is mixed and conveyed into the reagent chamber, the other portion passing into the saturator. At the same time sodium carbonate in solution of definite strength is delivered at a definite rate from a tank into the central reagent chamber. The chemical reaction between the lime water and sodium carbonate and the water to be softened takes place in this chamber. The interior of this chamber is lined by a series of spiral volutes, upon which the lime salts now thrown out of solution become deposited, and gradually falling down to the bottom of the central chamber, may be periodically removed. The water itself, gradually rising to the top of the volutes, is then passed upwards through filters, and passes out at the exit-pipe purified and softened.

It is interesting to note that the same mechanism, but with different chemicals, is being used to purify the sewage of Paris.

Quantity to be supplied per Head per Day.—The amount of water supplied per head per day in any community is necessarily determined by the total available amount at disposal. But there is a certain minimum quantity which is necessary. The average adult needs for nutrition, as a beverage and as a constituent of cooked or other food, from 70 to 100 ounces (3½ to 5 pints) daily. The soldier in barracks is allowed 15 gallons *per diem* for all purposes. The needs of a town are determined by the fact whether or not it is a manufacturing town, and what is the nature of the trade-processes. But in any case, the supply per individual may be apportioned as follows: (*A*) Dietetic: (1) cooking; (2) drink. (*B*) Sanitary: (1) personal ablution; (2) cleansing of clothing and home; (3) as a vehicle for sewage. If all of these needs are summed up, probably from 12 to 15 gallons per day may be considered as a fair minimum. For all purposes, however, in a manufacturing town, where much water is necessarily employed, in addition to the foregoing allowance for such requirements as animal nutrition and cleansing and for municipal purposes, as cleansing of streets and courts, fire-extinction, fountains, public baths and wash-houses, urinals, etc., a larger daily allowance is necessary, and the amount to be aimed at should not be less than 30 to 35 gallons per head daily; for although a certain allowance per head may be calculated from the total amount of water which leaves the reservoirs, it does not necessarily prove that such quantities are available to the consumers, because of waste from leaking mains and service-pipes, defective house water-fittings, and from wilful waste. Indeed, the amount of average waste has been reckoned to be from $\frac{1}{4}$ to $\frac{1}{3}$, or even a larger proportion, of the total supply from these combined causes. Parkes' estimate of the supply needed per head per day, on the average of all towns, is as follows:—

	Gallons.
Domestic supply (without baths or closet)	= 12
General baths	= 4
Water-closets	= 6
Unavoidable waste	= 3
Total house-supply	= 25
Town, and trade-purposes, and for animals in non-manufacturing towns	= 5
For exceptional manufacturing towns	= 5
Total	= 35

The daily amount per head available in different towns varies considerably. In London, the average amount is 28 gallons; in Liverpool, 30; in Paris, 31; in Edinburgh, 42; in Glasgow, 50; in Rome, 100; and in New York, 300; while in many towns it is less than 20 gallons.

Distribution of Water-Supply.—When populous places are to be supplied from natural or artificial upland collections of water, the relative altitudes of source of supply and area of distribution become of considerable importance, since if by gravity the water will flow from the source to the highest point of distribution, mechanical agencies can be dispensed with and money will be saved. Loch Katrine is 367 feet above sea-level, and Mugdock Reservoir, to which the water is led from the Loch and which is about six miles from the city of Glasgow, 317 feet. This relative difference of altitude, however, cannot always be secured, especially if the area of distribution covers a hilly tract of ground. In Glasgow, for example, one district at least cannot be supplied by gravity for this reason, and therefore an auxiliary pumping-station has had to be provided to drive the water to a reservoir situated higher than the houses to be supplied in that district. The following figure illustrates a gravitation water-supply. (Fig. 47.)

The water-supply of Manchester comes from Lake Thirlmere in Cumberland, that of Liverpool from deep wells, from Rivington, and from Lake Vyrnwy in Wales, and that of Birmingham from the watersheds of the rivers Elan and Claerwen, also in Wales.

From the source the supply may be either *constant* or *intermittent.* This must be determined by the relation of available amount of water in the reservoirs to the quantity required in the area of distribution: if it be abundant and greater than is needed, the supply should be constant; if, on the other hand, there be little margin to spare, it will probably be intermittent. The intermittent system of supply offers certain objections: first, it involves the need for erection of storage-cisterns in houses wherein sufficient water is stored against the period in the twenty-four hours when the main-supply is cut off. Such cisterns are often sources of water-pollution from dirt, dead animals as mice, rats, beetles, etc., from plaster, or from coal-gas, etc., if they are not covered. Second: owing to the main-pipes being alternately full and empty, there is risk of contamination from sewage, sewage-gas, or coal-gas, by reason of the in-suction at leaking points. These risks are substantial. It has been urged that this system, however, has certain advantages—viz. (1) there is less waste; (2) the water-fittings in houses need not be so strong. While the former may be true, it is difficult to see the force of the latter, except with respect to the water-fittings from the house cistern, since the pressure within the main-pipes and the service-pipes does not depend upon the constancy or intermittency of the supply, but upon the relative altitudes of source and point of distribution; in other words, upon the head of water. The great advantages of the constant system are: (1) the prevention of contamination in the main-pipes, since the pressure acts from within outwards, and (2) the avoidance of need of house-cisterns, with the attendant risks of contamination. Upon one occasion, by reason of continued ill-health of the inmates of a house, we examined the water-supply, and in the house-cistern, which was situated in a dark apartment containing bath and water-closet, we found the decomposing bodies of two rats and one mouse, in addition to dirty plaster. On analysis of the water, the existence of excess of free and albuminoid ammonia, organic matter, and nitrates showed that not only was pollution present, but that it had continued for some time. There is one unavoidable drawback in the constant system, and that is, when the water is cut off owing to repairs in mains, scanty supplies from drought, or other reasons. In such contingencies as the former, notice is usually given by the water-companies when possible, so that water may be stored for the time being. Upon the whole, therefore, the aim should be abundance of quantity, a constant supply, and free access, public and private, to sources of supply.

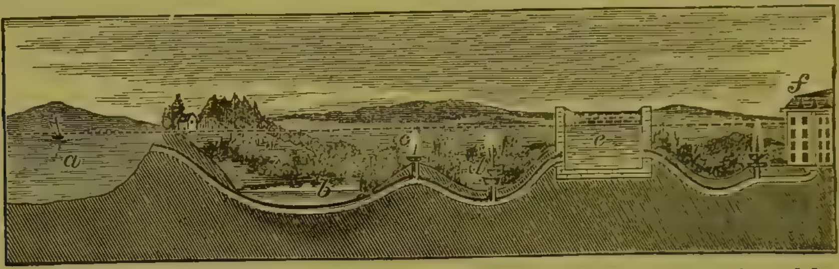

FIG. 47.—To illustrate Water-Supply by Gravitation. *a*=source of supply—a lake or reservoir; *b*=line of piping under pond or lake; *c*, *d*=fountains, to illustrate height to which the water will rise; *e*=storage cistern or reservoir; *f*=point of distribution, and limit to which water will rise.

Plumbo-Solvent Action.—Waters differ as to their power of dissolving lead, according to their composition. Soft waters, generally, have a plumbo-solvent power, due to the gases, oxygen and carbonic acid, which they contain in solution. But this statement must be received with a reservation. If a typical soft water, as that of Loch Katrine, be experimented with, it will be found that it readily and freely attacks a bright, untarnished surface of lead piping, but that it does *not* attack a dull, tarnished surface. Therefore, when it is declared that Loch Katrine water dissolves lead, that statement must be held to be only true of untarnished lead pipes, and not of tarnished. It is, doubtless, for this reason that lead poisoning is not prevalent in Glasgow and neighbourhood. Waters containing excess of chlorides, nitrates, nitrites and organic matter also dissolve the metal. Such organic matter is usually composed of peaty products. Certain waters of Lancashire, Yorkshire, and Derbyshire derived from moorland gathering-grounds exercise this action distinctly, and symptoms of lead-poisoning have appeared in the consumers. On investigation, it was believed to arise from the presence of ulmic, humic, crenic, and apocrenic acids in the peaty organic matter. Neech, of Halifax, in a report to the Health Committee of that town in February 1901, pointed out that its water-supply exercised a marked lead-dissolving action. He found that when the acidity of the water was 1·01, the amount of lead dissolved in one hour was 0·56 parts per 100,000, when the acidity fell to 0·7, the dissolved lead also fell to 0·18 parts per 100,000. He found that by adding lime to the filtering-beds at the reservoirs to the extent of 80 to 90 grains per gallon, the acidity of the water was reduced to 0·31, and the dissolved lead to 0·037 parts per 100,000, which amount he believes to be within the limits of safe use.

Robertson, medical officer of health of Birmingham, has declared at an inquiry held there that the water of that city had an effect upon lead. If a lead-lined kettle filled with water was allowed to stand on the hob all night, and was boiled in the morning, the water would contain lead.

In the urban district of Aberdare, Wales, lead-poisoning prevailed more or less every year, and in 1908 six deaths were certified as due to poisoning from lead contained in the drinking water. The waters from several of the storage-reservoirs on being examined were found to be acid in reaction and to be capable of dissolving lead. The water authorities were recommended to treat the water with chalk, and accordingly, in 1908, a chalk plant was installed. This treatment has proved successful, the recent analysis showing that the water, which before contained $\frac{1}{40}$th grain per gallon, is now lead-free.

This acidity of water as a main cause of lead-dissolving action seems to be corroborated by various facts. For example, after the long drought of 1887, during which the reservoir-supply of Sheffield fell much below normal, and when, therefore, it was believed that the water contained these acids in abnormally high proportion, a severe outbreak of lead-poisoning took place, which subsided on the water being restored to its usual level by rainfall. Some, however, are inclined to doubt the above explanation as the cause, and are more inclined to attribute the action to the work of micro-organisms. However, the fact remains that such waters do dissolve lead.

It is certain that peaty waters in some localities exercise this action, and that others in other localities do not. The interesting question then arises: What constituents exist in these waters which determine the difference of action ? This has not yet been definitely established: but there is some ground for believing that the presence or absence of silica is a factor of importance. One thing is quite clear, that if a water possessing this power of plumbo-solvent action be filtered through a bed containing a proportion of silica, as where crushed granite is used as a separate layer below sand, or if a small quantity of silica be added to the water, the plumbo-solvent action disappears. It does not appear to us that solution of lead by potable waters is referable solely to one cause, but that the main cause probably is acidity of the water in the service-pipes. The presence of a minute quantity of lead, even to the amounts of $\frac{1}{10}$th to $\frac{1}{20}$th grain per gallon, is a serious matter, seeing that lead is a cumulative poison, and if this were discovered in a preliminary investigation into suitable waters for a new supply, it would rightly necessitate rejection. But if this property is only discovered after the works are in operation, instant steps, by filtration especially and by other means, must be taken to rid it of this power. Probably the use of freshly slaked lime, or broken limestone incorporated in the filter-bed, or the use of block-tin or glass-lined house-pipes, or even wrought-iron pipes, where the water is not subjected to filtration, would produce the desired effect.

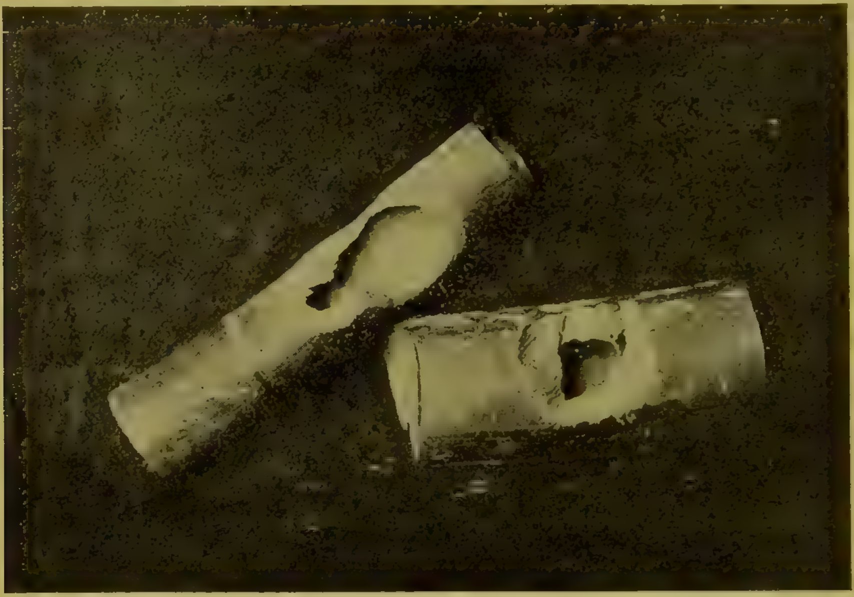

FIG. 48.—Water-pipes gnawed by Rats. The pipe on the left is 1 inch in diameter, and $\frac{1}{8}$th of an inch in thickness. The other is 2 inches in diameter and $\frac{3}{16}$ths of an inch in thickness. (In possession of Author.)

Hard waters also attack lead by reason of the excess CO_2 which they contain, but the salts of lead which are formed are insoluble, and therefore innoxious.

One of the most valuable contributions to the subject of lead-poisoning and water-supplies is that by Houston,[1] which deals with moorland waters in regard to their action on lead. The reason of the inquiry was the prevalence of lead-poisoning in certain populous centres in

[1] Thirtieth Annual Report to Local Government Board, England, 1900–1901.

England which were traced to lead-contaminated water.[1] In the Supplement to the twenty-third annual Report the results of the inquiries of Drs. Thomson and Berry on this subject are referred to. Houston's report dealt with the records of observations made at moorland gathering-areas selected at Burnmoor at typical pools and springs, and of mixed water in streams and reservoirs in regard to their chemical impurities and lead-dissolving power; as well as from the records of observations from the moorland gathering-grounds of 23 waterworks in Lancashire and Yorkshire, borough and urban. Out of 58 reservoirs examined by Houston, no fewer than 35 contained acid water possessing plumbo-solvent properties. The chemical tests employed in the investigation were (*a*) Hardness, by Clark's soap test, (*b*) Reaction, (*c*) Acidity, and (*d*) Plumbo-solvent power. The reaction was qualitatively found by an alcoholic solution of lacmoid (0·2 gramme of lacmoid dissolved in 100 c.c. of 10 per cent. alcohol). The test was to add to 10 c.c. of the water-sample a few drops of this indicator: if the merest trace of acid reaction existed in the sample, the purplish-blue colour of the lacmoid solution became changed to a red colour. If a water responded to this reaction, the amount of acidity was then estimated quantitatively by titrating 100 c.c. or more of the water against $\frac{N}{10}$ solution of sodium carbonate, phenolphthalein (0·5 gram in 100 c.c. of 50 per cent. alcohol) being used as indicator. The use of phenolphthalein, it must be observed, is open to objection when used as an isolated observation, but the objection loses force when that indicator is used for periodic examinations of the same water. For the estimation of plumbo-solvency, washed lead shot was used, the water to be examined being allowed to filter upwards through the shot. The filtered water, collected in 50 c.c. quantities, was tested for lead by ammonium sulphide, and the amount of lead dissolved found by testing the colour produced against lead-free distilled water to which had been added the requisite amount of a standard solution of lead acetate (1·66 grams of lead acetate per litre) of which 1 c.c. = 1 milligram of lead.

The following facts emerged from the inquiry: (1) Moorland gathering-grounds of water-supplies are usually rich in peat; (2) Moist peat was invariably found to yield an acid reaction; (3) The water from peat is always acid, the amount depending upon the amount of peat and the length of time the water has been in contact with it; (4) Acid water dissolves lead, and the degree of plumbo-solvency is mainly regulated by the amount of acidity; (5) Moorland spring-water is usually neutral, and not infrequently has slight acid-neutralising power; (6) Neutral waters do not dissolve lead appreciably; (7) Moorland supplies commonly combine both classes of water; (8) Rain-water is usually neutral, but in certain gathering-grounds is slightly acid; (9) Water derived from rocks rich in iron pyrites is usually acid, and attacks lead; (10) During dry weather, and especially toward the end of a period of drought, moorland supplies, being then chiefly of spring origin, are usually neutral; (11) During wet weather, and especially after storms of rain, moorland supplies are much more acid, and especially so immediately after a spell of drought; (12) Neutral waters sometimes act upon bright (*i.e.*, untarnished) lead by erosion, due to dissolved oxygen. Loch Katrine water does so readily, but does not attack tarnished or oxidised lead.

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[1] See *Supplement to Twenty-Third Annual Report of Local Government Board.*

In order to discover what was the originating cause of the acidity of peaty water, Houston carried out some bacteriological investigations, and he succeeded in isolating certain micro-organisms from peat which were found in their growth to possess the power of developing acid which produced plumbo-solvency, when cultivated in a sterile, neutral decoction made solely from peat.

The remedies for the prevention of plumbo-solvency which he proposed were the following:—(*a*) eliminating from the reservoirs water draining from specially peaty areas; (*b*) providing "leaping-weirs"—contrivances which automatically reject the first washings of peat after periods of drought; (*c*) neutralisation of acidity by adding to the surface of the sand filter a thin layer of slaked lime, and beneath the sand, a layer of limestone, and the subsequent addition of a trace of sodium carbonate to the neutral filtered water.

Outbreaks of lead-poisoning from water-supplies are wide-spread. In 1906, the medical officer of health of Pontypridd reported that lead-poisoning was very prevalent among the inhabitants of the district. Samples of the water-supply submitted to analysis showed unmistakably the presence of lead. Two samples from houses showed that whereas at 6 a.m. they contained 0·31 grain of lead per gallon, samples taken at 6.15 a.m. contained 0·17 grain per gallon. Some eighteen months before this in Merthyr and different parts of the Rhondda valley, dissolved lead was found in the water samples varying in amount from ·04 to ·0142 grain per gallon.[1]

In 1905, in a particular district of Vienna, several cases of lead-poisoning were discovered. The domestic water-supply of that city comes from glaciers and snowfields in the Alps some 116 miles from the city. Investigation showed that the source of the poison was lead contained in the water-pipes serving that district. The pipes in use are coated inside with tin, and some are composed of a compound of lead and tin. A main-pipe had burst in the form of a leakage, and the source of the leakage had been repaired by lead soldering, the water thus coming in contact with metallic lead. Altogether, 3,764 analyses were made, of which more than 3000 showed the water to be lead-free, but in about 100 samples there was found one milligram of lead per litre, in 50 samples, two parts per million, and in 25 samples, three parts per million. The inquiry revealed that the contact of the water with six inches of pure lead was sufficient to make the water unfit for human use.[2]

At Saddleworth, in 1907, an outbreak of plumbism was observed which, it was said, was due to the water supplied by the Ashton Joint Waterworks Committee. This water is acid from decomposing peat, and hence exercises a plumbo-solvent action on the lead service-pipes. The medical officer of health reported that hardly a day passed without reports of lead-poisoning being sent to him.[3]

[1] *B.M.J.*, vol. ii., 1906, p. 730.
[2] *B.M.J.*, vol. i., 1905, p. 1297.
[3] *Med. Press*, vol. i., 1907, p. 26.

An interesting case of lead-poisoning alleged to have had its origin in electrolysis of water-pipes has been reported by Roberts.[1] A man living in a cottage was found to be suffering from undoubted symptoms of plumbism. Examination of the drinking-water proved it to contain 0·14 grain of lead per gallon, and to be slightly turbid in appearance. The water to the cottage was supplied by a water-company which supplied a large area. The water purveyed by the company is obtained from a deep well in the chalk, is of high organic purity, and its original total hardness 14°, which is, however, reduced to 6° before delivery to consumers. The service-pipes were of lead. The water was not known to possess any plumbo-solvent property. To discover the cause in this case, a piece of the lead service-pipe to the cottage was cut out and examined. On its interior were patchy lumps, which proved to be of lead carbonate. These projected about one-eighth of an inch above the internal surface of the pipe, and were easily detached by bruising them with the finger. The cottage in question was the entrance-lodge to a large house about 200 yards off. Midway between was an electric-light station, which supplied the large house but not the cottage. The Water Company's engineer was of opinion that the cause of the lead in the water was electrolysis caused by a leak from the electric cable. The leak amounted to 1·8 volts, an amount sufficient to cause electrolysis. The lead service-pipe to the cottage from the main—about 150 yards in length—having been examined at various points in that length, it was found to be most affected near the cottage. Samples of water from other houses in the neighbourhood, including one from a cottage a few yards only from the electric station, were found on examination to be lead-free. It did not appear to the recorder of the foregoing facts, nor does it seem to us, that the explanation is completely satisfactory.

Zinc-poisoning, also, is not unknown. At page 631, vol. i., some cases will be found recorded as having occurred abroad under circumstances where the supply of drinking-water was collected from the rainfall on galvanised-iron roofs. Such conditions are not likely to occur frequently in this country.

Another enemy of water-pipes is rats. These rodents will attack pipes in their quest for water, and for the same reason are often found drowned in cisterns. The accompanying figure illustrates pipes in our possession which have been gnawed through by rats. (Fig. 48.)

Iron pipes, like lead pipes, are liable to oxidation, both externally and internally. The rust which forms in the interior offers a series of nuclei or foci for the deposition of organic matter and mineral matter in suspension, until sooner or later, diminution in rate of flow is produced by the lessened calibre. The interior of water-mains and service-pipes of iron ought to be coated either with Angus Smith's composition (resin, oil, pitch, etc.) or by Barff's process, which causes a layer of magnetic oxide to be formed on the interior of the pipe. The former, however, for many months after, imparts a distinct tarry taste to the water.

SUPERVISORY CONTROL OF WATER-SUPPLIES.—At the outset, it must be said that the total water-supplies of cities and towns in the kingdom are in the hands either of Local Authorities or of private companies; that by far the bulk of them are in the hands of the former; and that of the latter, there are, so far as we know, but *four* in all Scotland, whereas in England the number is much greater, there once being eight in London alone. Supervisory control is necessary whether the water-company be the municipality or a private company, but it has been suggested, for different reasons, that in the case of private companies there should be greater freedom of access to Sanitary Authorities and water-consumers upon the lands of the water-company for the purposes of inspection and taking samples, if desired, than at present obtain. Supervisory control, therefore, divides itself into two kinds, viz.: (1) that which the vendors of the water ought to take for the purity of the water sold to consumers; and (2) that which the consumers ought to have for their protection where there is reason to believe the vendors are neglectful.

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[1] *B.M.J.*, vol. 1., 1906, p. 139.

I. The nature of the supervisory control on the part of the vendors ought to include the following, viz.:—

(*a*) A knowledge of the original character and natural history of the water-supply;
(*b*) Inspection of the source, collecting-grounds, and works, which should be periodic, systematic, continuous; and
(*c*) Chemical and bacteriological examination of samples of the water taken from various points of the system, at regular, short intervals.

Under the first head would be included not only amount, quality as to hardness or softness and power of plumbo-solvent action, but also the fauna and flora of the water. When such data are known, any alterative additions may the more easily be detected in the subsequent periodic examinations. The appearance of certain low forms of vegetable life affords indices of change. Berlin, for example, had to abandon the water from wells sunk near the Tegeler Lake by reason of the development of *Crenothrix;* and the integrity of the Rotterdam supply was imperilled for some time for the same reason. This vegetable organism best thrives in the presence of organic matter and protoxide of iron, and it imparts to a water a disagreeable odour and taste. The unexpected presence of *Beggiatoa alba* in an Irish water-supply, rendering as it did the water turbid, was found to be due to decomposing water-plants in the reservoir. Mez[1] in his work on the microscopic examination of water has done much to give insight into the import of the presence of such organisms.

Waters may develop special appearances, characteristics, and properties from protean forms of life present in them. In America, certain forms of Infusoria have been found to impart a fishy odour to water, as *Uroglena Americana.* A fresh-water sponge, *Spongilla fluviatilis,* caused the water of Boston, U.S.A., in 1878 to acquire a cucumber odour. *Volvox globator* gives water a fishy odour and taste; *Bursaria gastris,* an odour of sea-weeds; *Asterionella* and *Tabellaria*—both diatoms—an aromatic odour; a fresh-water alga, *Conferva bombycina,* in July, 1891, caused the water of Bolton, Lancashire, to acquire a fishy odour and a taste of stale fish; *Chara foetida* imparts a fetid odour. The unfiltered water of Lake Vyrnwy supply to Liverpool was found to contain a gelatinous thread organism, belonging to the *Cladothrix*, *Leptothrix*, and *Crenothrix* group, which possessed the power of dissolving and absorbing iron, and depositing it as oxide. Its presence, indeed, compelled the Liverpool Corporation to filter that supply because of the deposits which it had commenced to cause to be formed on the interior of the main pipes, which, in turn, reduced the water-delivering power of the mains. The presence of *Beggiatoa alba* or any member of that family in a prospective source of water-supply ought to be taken, generally, as an evidence of sewage-pollution.

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[1] *Mikroskopische Wasseranalyse,* Berlin, 1898.

Under the second head, it may be said that however intimate may be the character of the examination of water, ocular inspection of the sources of supply cannot be omitted. By it the grosser forms of pollution may be detected in their inception. There can be no reasonable doubt that if systematic inspection of the gathering-grounds of many of the supplies which have given rise to epidemics of enteric fever had been in operation, such would either have altogether been prevented, or the effects of pollution at least minimised. It is only necessary to quote from the report of Mr. Percy Adams regarding the cause of the Maidstone epidemic to show this. In speaking of the condition of the springs from which the supply came, he said that one of them was situated "about 50 yards from a privy which, at the time of our visit, was in a disgraceful condition, a large deposit of fæces decomposing and flooding the ground with its constituents, and in too close proximity to the very superficial source or gathering-ground; and, taking into consideration the very heavy rainfall in August [the epidemic began in September], must have been very widely distributed over the surrounding area." Again, in 1898 attention was called to the conditions of the water-supply of Aberdeen, which is taken from the river Dee. Upon investigation it was found that a spout of sewage was entering the aqueduct at the rate of about 700 gallons per day, and, in addition, within 10 feet of the aqueduct there was a cesspool and an area of sewage-saturated soil. In like manner may be discovered manurial contamination from arable land, carcases of dead animals, and other gross pollutants. Such inspection, therefore, must be regular, systematic, and especially in the case of deep wells and springs, minute.

The only absolute protection against possible pollution of gathering-grounds is control over the gathering-grounds, by municipal water-purveyors purchasing the rights over the water-shed against erection of houses or other buildings within the water-shed. Glasgow paid a sum of £17,000 for the rights over the water-shed of the Loch Katrine supply, and the corporations of Liverpool, Manchester, and Birmingham have likewise paid large sums of money for the like purpose.

Chemical Analysis and Bacteriological Examination are both demanded in the examination of potable waters. They are complementary of each other. Chemical methods have their limitations, hence they ought to be supplemented by bacteriological methods; the former can perfectly detect inorganic substances suspended or dissolved in water, but opinion derived from them in respect of organic matters is as likely to be wrong as right. This must be considered as having special bearing upon individual analyses; it does not apply so forcibly when systematic analyses at short stated intervals cover a long period. If we start from the fact that water-borne diseases are microbic in causation, the need for determining the presence or absence of specific organisms becomes not only evident but urgent. Their detection may be difficult, but it is none the less desirable. In all cases, therefore, where the original source of supply is liable to be, or is actually known to be, contaminated, bacterioscopic investigation cannot be neglected, but should continuously be employed for testing the efficiency of filtration. A well-defined plan and exactness of method of bacteriological examination of water should now be formulated, as has been done for chemical examination. A committee of bacteriologists was appointed by the American Public Health Association to formulate such a scheme of examination, and they reported in 1898 that certain tests should be applied to all micro-organisms found in water, viz. : (1) Source and Habitat ; (2) Morphological characters ; (3) Biological characters, with reference to (*a*) cultural characteristics, (*b*) bio-chemical features, and (*c*) pathogenesis. They further recommended the adoption of (1) uniformity of methods of preparation of culture media, and their range ; (2) uniformity of reaction of media, according to a test scale detailed in the report ; and of many other important points. Such a scheme and lines of uniform procedure might well be considered by bacteriologists in this country for bacteriological examinations of water, as were laid down by the Society of Public Analysts for chemical examination.

It is absolutely essential, in the case of waters derived from known polluted sources and which have to be subjected, therefore, to careful continuous filtration, that the results of the filtration should be checked by regular bacterioscopic examination of the filtered water. This is done, for example, by the Metropolitan Water Board of London, which has eight waterworks under its control supplying daily two hundred million gallons to six and three-quarter million persons. These waterworks derive their water from three sources of raw supply and from numerous deep wells, and most have filter-beds. All the works are visited five times each week and samples collected from the separate filter-wells in rotation, the samples being taken in sterilised bottles which are packed in ice for transmission to the laboratory. During November, 1905, for example, the waters of the Thames, the New River, and the Lee were each examined bacteriologically over twenty times, and 800 samples were taken from the filter-beds, while 44 samples of the unfiltered water from the Kent wells were also examined, thus making in all for November alone about 1000 samples. The method of bacterioscopic examination as carried out by Houston, the director of water examinations, is as follows :—(1) Estimation of total number of bacteria per c.c. which grow on nutrient gelatine at 20° to 22° C. ; (2) Examination for the *B. coli communis*, as evidenced by a colony producing acid and gas when cultivated in a medium containing peptone glucose and bile salts (taurocholate and glycocholate of soda), when a pure culture of a coli-like bacillus ferments glucose, and when such a colony produces (*a*) fluorescence in broth containing neutral red, (*b*) acid and gas in lactose peptone cultures, (*c*) indol in peptone water, and (*d*) acidity and clotting in litmus milk. These last-named collective results being formulated in the mnemonic word "*flaginac*" from *fl* = fluorescence, *a* = acid, *g* = gas, *in* = indol, and *ac* = acidity and clotting.

Examination is also made, (3) for spores of *B. enteritidis sporogenes* (Klein).

The chemical examination consists of quantitative estimations of (*a*) ammoniacal nitrogen, (*b*) albuminoid nitrogen, (*c*) oxidised nitrogen, (*d*) chlorine, and (*e*) absorption of oxygen from permanganate of potash.

Houston has reached the conclusions that the presence of streptococci in a water is indicative of very recent pollution, the presence of *B. coli communis*, of comparatively recent pollution, and that the presence of *B. enteritidis sporogenes* does not indicate necessarily pollution from recent animal evacuations; that streptococci are absent from 10 c.c. or more, *B. coli*, from 1, 10, or 100 c.c. or more, and *B. enteritidis sporogenes*, from 100 c.c. to 500 c.c. or more, of pure waters; and that it is not necessary to demonstrate in a polluted water the definite presence of pathogenic organisms in order to prove that there is danger in drinking such water.[1]

II. *The Supervisory Control on the part of the Consumers.*—Complaints have from time to time been made that, owing to want of enforcement of their powers, private water-companies fail in their duty to the consumers to conserve the purity of their supplies; that Local Authorities, whose districts are supplied by water from such companies, have no executive powers in protecting their ratepayers against pollution of supply, have no right of entry to the gathering-grounds, reservoirs, or works, cannot take samples, and have no means of satisfying themselves that the area of reservoir-storage is ample enough, or that the purification processes are efficient, or are efficiently used for supplying a pure water. It has been urged that if such powers were granted, the companies would be apter to enforce their powers against pollution, that epidemics of water-borne diseases would diminish in number, and that greater benefit would accrue to the public health. But it must be pointed out that private water-companies are performing the duty which municipal or urban authorities might themselves have been, nay perhaps, ought to have been, performing all the time; and, further, that even now, a Local Authority, or a group of Authorities, can relieve itself of its undesirable position by purchasing the undertaking from the company, under section 51 of the English Public Health Act, or under section 126 of the Act of Scotland. This depends, of course, upon a willing buyer and a willing seller, upon the desirability or undesirability of purchase of existing works, and upon other factors. But so long as the present position remains, right of reasonable access to water-works belonging to private companies ought to be possessed by Local Authorities of the areas of supply. This view has commended itself to the English Local Government Board, which has drawn up certain clauses for future legislation as follows:—

Clauses suggested by Local Government Board of England for the Protection of Sources of Water-Supply.[2]

Penalty for Failure to supply Pure and Wholesome Water (10 Vict. cap. 17).—1. If the Company fail to provide and keep such a supply of pure and wholesome water as is required by section 35 of the Waterworks Clauses Act, 1847, they shall, unless prevented by frost, unusual drought, or other unavoidable cause or accident, be liable for the first offence to a penalty not exceeding £20, and to a penalty not exceeding £5 for every day on which the offence is continued after conviction; and such penalties may be recovered summarily before a Petty Sessional Court.

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[1] *B.M.J.*, 21st Dec. 1901.

[2] *Report by the Med. Officer, Local Gov. Board*, Appendix B., No. 8, 1900.

2. Any offence under this section may be prosecuted by any Local Authority acting in the execution of the Public Health Acts in any part of whose district the Company supply water for domestic purposes.

3. All penalties recovered under this section shall be applied in such manner as the Court may direct.

Power to take Samples of Water.—1. For the better enforcement of the provisions of section 35 of the Waterworks Clauses Act, 1847, any medical officer of health or other person authorised by a Local Authority, acting in the execution of the Public Health Acts for any districts in any part of which water is supplied by the Company for domestic purposes (producing, if required, a certificate of his personal authority signed by the clerk to the Local Authority), shall be entitled at any time, on giving not less than six hours' notice to the Company, to take and carry away samples of water from any land, reservoir, work, building, filter-bed, main-pipe, stand-pipe, or stop-cock of the Company from, through, or by which a supply of water is given, and may for that purpose enter upon any lands or premises of the Company. Any person who obstructs or molests such medical officer of health or other person authorised as aforesaid, shall be liable to a penalty not exceeding £20 for each such offence; and such penalty may be recovered summarily before a Petty Sessional Court.

2. Any water consumer may at any time, on giving such notice as aforesaid, take and carry away samples of water from any land, reservoir, work, building, filter-bed, main-pipe, stand-pipe, or stop-cock of the Company from, through, or by which a supply of water is given, and may for that purpose enter upon any lands or premises of the Company.

3. Any samples shall be taken in triplicate, and shall forthwith be respectively sealed up and marked by the person taking the same, who shall leave one of such samples with the Company, or an officer or other agent of the Company, and may submit another for examination, if he thinks fit, and shall retain the third for future comparison if required.

4. The Company shall be entitled to be represented by an officer or other agent when the samples are taken, sealed up, and marked.

5. For the purposes of this section " water consumer " means any person who is supplied by the Company with water for domestic purposes, or who pays, or is liable to pay, any rate for such a supply.

Pollution of Sources of Supply.—1. For the better discovery of any pollution of the water obtained or supplied by the Company, any officer of the Company authorised in that behalf by the Company, and any medical officer of health for any district whereof any part is supplied by the Company with water for domestic purposes, authorised in that behalf by the Local Authority for such district, may at any time between the hours of nine in the forenoon and four in the afternoon, on producing, if required so to do, a certificate of his personal authority signed by the secretary of the Company in the case of an officer of the Company, or by the clerk to the Local Authority in the case of the medical officer of health, enter on any lands or premises from which the water is obtained or supplied, whether immediately or otherwise by the Company, and may take and carry away samples of any water or of any matter, substance, or liquid which may appear likely to cause pollution to the water of the Company, or whereby such water may be fouled.

2. Any samples shall be taken in triplicate, and shall forthwith be respectively sealed up and marked by the person taking the same, who shall leave one of the samples with the person having custody of the premises, and may submit

another for examination, if he thinks fit, and shall retain the third for future comparison if required.

Power to enter Lands and Premises for the purpose of taking Samples and discovering Causes of Pollution.—1. If any water consumer, authorised by section 2, or any person authorised by or under section 3, to take and carry away samples or to enter on any lands or premises is refused permission so to do, any justice having jurisdiction in the place where the land or premises is or are situate, on complaint thereof on oath by such person (made after reasonable notice in writing of the intention to make the same has been given to the person having custody of the premises) may, on reasonable cause being shown, by order, require such person to admit the person authorised as aforesaid upon the premises during the hours mentioned in the order, and to permit and give all facilities to him to take and carry away such samples as aforesaid.

2. Any order made under this section shall continue in force until the purposes for which such order was made are completed; and any person who refuses to obey an order so made shall be liable to a penalty not exceeding £5 for each such offence, such penalties to be recovered summarily before a Petty Sessional Court.

Law Respecting Water-Supplies

England and Wales

The law is contained in—

(*a*) Public Health Act, 1875: Sections 51–70, and 175;
(*b*) Public Health (Water) Act, 1878: Sections 3–10;
(*c*) Local Government Act, 1894; Sections 8 and 25;
(*d*) Waterworks Clauses Act, 1847.

I. Public Health Act, 1875.

Local Authorities and Providing a Water-Supply.

Section 51. Provides that any Urban Authority may provide their district or part thereof, and any Rural Authority, their district or any contributory place therein, or any part of such contributory place, with a supply of water proper and sufficient for public and private purposes, and may—

(1) Construct and maintain waterworks, dig wells, and do any other necessary acts; and

(2) Take on lease or hire any waterworks, and (with the sanction of the Local Government Board) purchase such waterworks or any water or right to take or convey water either within or without their district, and any rights, powers, and privileges of any water-company; and

(3) Contract with any person for a supply of water.

Construction of Waterworks in District already supplied by a Water-Company.

Section 52. Enacts that the Local Authority (L. A.), before commencing to construct waterworks within the limits of supply of any water-company empowered by Act of Parliament to supply water, shall give written notice to such water company, stating the purposes and extent to which water is required by the L. A.

It shall not be lawful for the L. A. to construct such waterworks if and so long as any water-company is able and willing to supply a proper and sufficient amount of water for all reasonable purposes to such L. A.; any differences between the L. A. and the water-company to be adjusted by arbitration in manner provided by this Act.

Construction of Reservoirs.

Section 53. At least two months before commencing to construct any reservoir (other than one which will hold not more than 100,000 gallons), the L. A. must give notice by advertisement in one or more local newspapers circulated in the district where the reservoir is to be constructed. If any person objects to such construction, he must give notice in writing of such objection to the L. A. within said two months, and the work shall not be proceeded with without the sanction of the L. G. B. after inquiry held by said L. G. B., or unless such objection is withdrawn.

The L. G. B., in the case of objection having been made, may hold an inquiry on application of L. A., on the spot by an inspector, who, after receiving the report of the inspector, may allow or disallow by order such scheme, or, if allowed, with or without modifications.

Section 54. Gives power of carrying mains for supply.

L. A. to keep pure and wholesome water in waterworks and at suitable pressure in pipes.

Section 55. Enacts that L. A. shall provide and keep in any waterworks belonging to them a supply of pure and wholesome water, and at such pressure in the pipes as will enable the water to rise to the top storey of the highest dwelling-place within the district supplied.

Section 56. Gives power to L. A. to charge water-rates and rents.

Section 57. Incorporates the Waterworks Clauses Act, 1863, and certain provisions of the Act of 1847 of same title.

Section 58. Empowers L. A. to supply water to consumers by measure.

Section 59. Enacts that the registers of meters are to be taken as evidence of amount of water consumed.

Section 60. Enacts a penalty for injuring water-meters.

Section 61. Empowers L. A., with consent of L. G. B., to supply water to adjoining districts; any dispute arising to be settled by arbitration.

Power to L. A. to require houses to be supplied with water in certain cases.

Section 62. On report of surveyor of L. A. that any house within their district is without a proper supply of water and that such house can be furnished therewith at a cost not exceeding the water-rate authorised by the local Act, or, in the absence of any local Act, at a cost not exceeding twopence per week, or at such other cost as the L. G. B. may, on application of L. A., determine as reasonable under all the circumstances, the L. A. may require the owner of such house to supply a sufficient supply of water within a time to be specified in the order. In the event of the owner failing to comply with the terms of the order, the L. A. is empowered to have the work done and to recover the costs of the same, the expenses, and the water-rates from the owner summarily.

Details the powers of a Water-Company for supplying Water to Local Authority.

Section 63. The water-company, by special resolution of its members, in the case of a company registered under the Companies Act, 1862, or by a resolution passed by three fourths of its members in the case of a company not so registered, may contract to supply water or lease their waterworks to any L. A.

All waterworks for gratuitous supply of water to be vested in and maintained by Local Authority.

Section 64. Vests all public cisterns, pumps, wells, reservoirs, aqueducts and any other works used for the gratuitous supply of water to the inhabitants of the district in and under the control of the L. A., and such L. A. may cause the same to be maintained or may substitute and maintain and plentifully supply with pure and wholesome water other such works equally convenient.

Local Authority may supply gratuitous water to public baths, etc.

May erect necessary works for same.

Section 65. Empowers L. A. to supply, when deemed fit and proper, water to public baths and wash-houses, and for trading and manufacturing processes; and L. A. may, if they deem fit, construct any works for the gratuitous supply of water to such public baths and wash-houses.

Section 66. Enacts that the L. A. shall institute fire-plugs and all necessary works and machinery for an efficient supply of water in case of fire, and shall paint or mark on buildings and walls of streets such designs as will indicate position of such fire-plugs, etc.

Section 68. Enacts penalties against any who pollute water-supplies by gas-washings.

Legal action against pollution of watercourses by sewage.

Section 69. Empowers L. A., with sanction of Attorney-General, either in their own name or in the name of a consenting person, to take proceedings for the purpose of protecting any watercourse from pollutions arising from sewage, either within or without their district.

Section 70. Empowers L. A. to close polluted wells, tanks, cisterns, public or private. The Court may, before deciding a cause, ask that the water complained of be analysed. Section 46 of the P. H. Acts Amendment Act, 1907, gives power to a Local Authority, on the report of the M. O. H., to close any well or disused well which is prejudicial to health.

Power to close polluted wells, etc.

Section 175. Provides that any L. A. may purchase, lease, sell, or exchange any lands within or without their district, and may buy up any water-mill, weir, or dam which interferes with the water-supply of their district.

Purchase may be made by voluntary arrangement, or by compulsion, in which latter case the Lands Clauses Consolidation Acts, section 176, is included or incorporated in this Act. (See also Lands Clauses Act, 1845, section 6, and Settled Land Act, 1882, sections 3 and 58.)

II. Public Health (Water) Act, 1878.

Section 3. Enacts that it is the duty of a Rural Authority to provide and require provision of a sufficient water-supply to every occupied dwelling-house within their district which has within reasonable distance an available supply of wholesome water, and at a reasonable cost, not exceeding a capital sum the interest on which at the rate of 5 per cent. per annum would amount to twopence per week, or at such other cost not exceeding a capital sum the interest on which at the same rate would amount to threepence per week.

Rural Authority to provide and require sufficient water-supply to houses at certain costs.

Section 4. Gives right of appeal by owner in the case of above demand on the following grounds :—

(1) That the supply is not required ;

(2) That the time-limit in the order is insufficient to enable the order to be complied with ;

(3) That it is impracticable to supply the same at a reasonable cost ;

(4) That this duty ought to be done by the L. A. itself ; and

(5) That the expense in whole or in part of conforming to the order of the L. A. should be a charge upon the district.

Right of appeal by owners in case of demand for such supply to houses.

Notice of objections to be lodged within 21 days, and the cause to be determined (1) by a court of summary jurisdiction, or (2) on order, after memorial, by the L. G. B.

Section 6. Makes it unlawful for houses in rural districts to be erected or rebuilt without sufficient water-supply, unless it be shown by certificate by inspector of nuisances of the district that a sufficient supply is provided within a reasonable distance.

Houses not to be erected or rebuilt without sufficient water-supply within reasonable distance.

Section 7. Enacts that it shall be the duty of every Rural Sanitary Authority to ascertain from time to time the condition of the water-supply within their district.

Rural Authority to ascertain condition of supply in district.

Section 8. Gives power, after application of L. A. to L. G. B., to define "reasonable cost" under section 62 of the P. H. Act, 1875 ; and L. G. B. may fix, by order, a general scale of charges for the whole or any part of the district of such L. A.

Power to L. G. B. to define "reasonable cost."

Section 9. Empowers a L. A. to rate for water-supply by stand-pipes.

Section 10. Gives power to levy water-rates.

Note.—According to section 3 of this Act, no owner can be compelled to spend more than £8 13s. 4d., or after sanction by the Local Government Board, more than £13 as a maximum sum—these being the capital sums the interest on which at 5 per cent. will yield twopence or threepence per week respectively—in providing a satisfactory supply of water to single houses or small groups of houses. The Local Government Board, moreover, has declared that where an owner possesses a number of cottages, even in a row together, the cost of outlay must include the supply of water to each cottage. Hence an owner cannot be compelled to spend £20 in digging a well for three or more cottages, unless the well is so near that each cottage is supplied with its individual pump. The P. H. (Water) Act would seem, therefore, to have failed in its intention.

By the Local Government Act, 1894, section 8, a Parish Council is empowered by agreement only to acquire any land, to legally utilise a water-source for a water-supply, and to contribute, in whole or in part, toward the cost of the same. Should a Rural District Council fail to provide water-supplies for the district under their jurisdiction, and should a complaint be made by a Parish Council to the County Council on that matter, the power of providing such supply is transferred to the County Council, who may themselves, or, in terms of section 299 of the Local Government Act, may appoint a person to, carry through a scheme.

Scotland

The law respecting water-supplies in Scotland is comprehended in the following Acts :—

(*a*) The Public Health (Scotland) Act, 1897; Sections 124–132.
(*b*) Local Government (Scotland) Acts, 1889 and 1894.
(*c*) Waterworks Clauses Acts, 1847 and 1863.
(*d*) Railways Clauses Consolidation (Scotland) Act, 1845.
(*e*) The Lands Clauses Acts.
(*f*) Burgh Police (Scotland) Act, 1892; Sections 257–269.
(*g*) Burgh Sewerage, Drainage, and Water-Supply (Scotland) Act, 1901.

I. Public Health (Scot.) Act, 1897.

Section 124. In the case of burghs subject to the provisions of the Burgh Police (Scot.) Act, 1892, or having a local Act for police or other purposes, nothing in this Act shall prejudice the provisions of any of the said Acts in regard to the provision of a supply of water for the domestic use of inhabitants and for sanitary and other purposes; provided that in the Burgh Police Act and in the Lands Clauses Acts the term "land" shall include water and any right or servitude to or over land or water.

L. A. to require owners to obtain supply to houses.

Section 125. In the case of any occupied house within the district of any Local Authority, other than the L. A. of a burgh, being without a proper supply of wholesome water at or reasonably near the same, the L. A. shall require the owner to obtain such supply and to do all such works as may be necessary for that purpose. Failing to do so within twelve months after due notice, the L. A. may themselves obtain such supply and charge owner with costs, or in the case of two or more houses, may apportion expenses between the owners, dispute as to apportionment to be determined by Sheriff.

Nothing in this section, however, shall relieve the L. A. from the duty of providing their district or any part thereof with a supply of water where a general scheme for such supply is required and can be carried out at reasonable cost.

The word "house" in this section includes schools, factories, and other buildings in which persons are employed.

Note.—There is no power in this Act to compel owners to introduce water *into* houses.

L. A. may acquire and provide water for domestic supply and for sanitary and other purposes.

Section 126. (1) The L. A., if they think it expedient, may acquire and provide or arrange for a supply of water for the domestic use of inhabitants and for sanitary and other purposes, and for that purpose may acquire and conduct water from any lake, river, spring, or stream, may dig wells, make and maintain reservoirs, may purchase, take on lease, hire, construct, lay down, and maintain such water-works, pipes, and premises, and do all such works as shall be necessary for the aforesaid purpose, and may themselves supply water, or contract or arrange with any other person to furnish the same. For this purpose the L. A.

shall be held to have all the powers and rights given to and be subject to all the obligations imposed on promoters of undertakings by the Lands Clauses Acts as amended by this Act.

Provided, also, that it shall not be lawful for the L. A. to provide or supply water within the area which any L. A., or any company established by Act of Parliament or empowered by Provisional Order, is authorised to supply with water, unless the L. A. shall previously have purchased or acquired the undertaking of such L. A. or company.

Note.—There is nothing in this Act as to provision of water for fire-extinction; probably, however, the L. A. may supply gratuitously water for such purposes. The cost of providing fire-plugs may fairly be charged against the public health assessment.

L. A. may, if they have surplus water, supply water to baths and wash-houses and for manufacturing purposes.

(2) The L. A. may, if they have surplus water after fully providing for what is required for domestic and sanitary purposes, supply water from such surplus to public baths and wash-houses, or for trading or manufacturing and all other than domestic purposes, on such terms as may be agreed upon between the parties: provided that when water is thus supplied from such surplus, it shall not be lawful for the L. A. to charge the persons so supplied both with the portion of the special water-assessment applicable to the buildings supplied, and also for the supply of water obtained, but the L. A. may do the one or the other.

May supply water gratuitously and maintain public cisterns, pumps, wells, etc.

(3) The L. A. may cause all existing public cisterns, pumps, wells and other waterworks for the gratuitous supply of water to inhabitants to be continued, maintained, and plentifully supplied with water, or may substitute other such works equally convenient, and may, if they think fit, provide and gratuitously supply water for public baths or wash-houses established otherwise than for private profit or supported out of the rates.

Power to carry water-mains within district.

(4) The L. A. shall have the same powers and be subject to the same restrictions for carrying water-mains within their district as they have and are subject to for carrying sewers within their district by the law for the time being in force.

Pollution of water-supplies by manufactory products.

Section 127. Enacts that any person engaged in the manufacture of gas, naphtha, paraffin, vitriol, or dye-stuffs, or any other deleterious substance, or in any trade in which the refuse produced in such manufacture is used, who shall at any time cause or suffer to be brought or to flow into any stream, reservoir, aqueduct, well, or pond, or place for water, constructed or used for the supply of water for domestic purposes or into any pipe or drain communicating therewith, any product, washing or other substance produced in any such manufacture, or shall wilfully do any act connected with any such manufacture whereby the water in any such stream, reservoir, etc., shall be fouled, and any person who shall wilfully do or permit to be done any act whereby the water in any stream, reservoir, etc., constructed or used for the supply of water for drinking or other domestic uses shall be fouled, shall forfeit for every such offence a sum not exceeding fifty pounds.

Section 128. Provides for the recovery of such penalty with expenses during continuation of offence or within six months after it shall have ceased.

Section 129. Provides for a daily penalty during continuation of offence.

Local Authorities may combine for water-supply.

Section 130. Empowers two or more Local Authorities to combine for the purpose of executing or acquiring an interest in or maintaining any works by this Act or any other Act authorised in regard to water-supply that may be for the benefit of their respective districts.

Special Water-Supply Districts.

Section 131. Makes provision for establishment of water-supply districts. Procedure. (1) A requisition must be sent to a L. A. by a Parish Council or by not fewer than *ten* ratepayers within the district, in writing;

(2) Such requisition must be sent to a L. A., not being the L. A. of a burgh;

(3) On receipt of such requisition the L. A. shall be bound to meet after 21 days' notice, or if the L. A. itself shall so resolve, it may meet after 21 days' notice.

(4) The L. A. shall at such meeting, whether a water-supply has been provided or not, consider the propriety of—

(*a*) Forming part of their district into a special water-supply district; or

(*b*) Enlarging or limiting the boundaries of a special water-supply district; or

(*c*) Combining a special water-supply district with another special water-supply district; or

(*d*) Enlarging or limiting the boundaries of both or either of such special water-supply districts, and combining the same or parts thereof; or

(*e*) Determining that any special water-supply district shall cease to exist as a special water-supply district, or that any such combination shall cease.

(5) The resolution of the L. A. shall determine all questions regarding the payment of any debt which may affect any district or special water-supply district, and the right to impose and the obligation to pay any assessment affected by such determination, and shall fix the date at which such determination shall take effect.

(6) Such resolution shall be published in one or more newspapers circulating in the district or by posting handbills throughout the district.

(7) A copy of such resolution shall be sent to the L. G. B., and when the L. A. is a district committee, to the County Council.

(8) Production of such newspapers or handbill or a certificate under the hand of the clerk of the L. A. shall be sufficient evidence of publication of such resolution.

(9) Within 21 days after the date of first publication of such resolution, it shall be competent for any person interested to appeal against the resolution to the Sheriff.

(10) The Sheriff, not being a Sheriff-substitute resident within the district, may either approve or disapprove of such resolution. If he disapprove, he may either find that no special water-supply district should be formed, or he may enlarge or limit the special district as defined by the resolution of the L. A. If he approve, he may find that a special water-supply district should be formed, and may define the limits thereof; or he may find that such a special water-supply district or part thereof shall be combined as craved, or that such combination shall cease, or that such district or districts shall, as such, cease to exist.

(11) The decision of the Sheriff shall be binding and shall be final, except where it is pronounced by a Sheriff-substitute, in which case it may be appealed to the Sheriff-principal.

The order of the Sheriff shall determine all questions regarding the payment of any debt which may affect any district or special water-supply district, and the right to impose and the obligation to pay any assessments affected by his determination, and shall fix the date at which such determination shall take effect; a copy of such order shall be forthwith published in one or more newspapers circulating in the district or by the posting of handbills throughout the district, and shall be transmitted to the L. G. B., and to the County Council.

It shall not be competent to appeal to the County Council against any resolution of a district committee under this section.

Nothing in this Act shall prejudice the provisions of sub-sections one and two of section 81 of the Local Government (Scotland) Act, 1889, as amended by the Local Government (Scotland) Act, 1894.

[These provisions are:—Section 81. With respect to special drainage districts or special water-supply districts, the following shall have effect:

(1) Where a special water-supply district has been formed in any parish under the Public Health Acts, the District Committee may, subject to regulations made with consent of the County Council, appoint a sub-committee for the management and maintenance of water-supply works, which sub-committee shall in whole or in part consist of parish councillors of the parish or parishes in which the special district is situated, whether such parish councillors are or are not members of the district committee.

(2) Where a special water-supply district is partly within a county and partly within a burgh or police burgh, the sub-committee, appointed as aforesaid, together with such number of the Town Council or Police Commissioners (as the case may be) of such burgh or police burgh as, failing agreement, the Secretary for Scotland may determine, shall be charged with the management and maintenance of the water-supply works within such special water-supply district.

Section 44 (9) of the Act of 1894 provides that the number of a sub-committee appointed under the previous section (section 81) may, failing agreement between a District Committee or County Council and a Town Council or Commissioners of a police burgh, be determined by the Secretary for Scotland.]

Section 132. Indicates the parts of the Waterworks Clauses Acts which are incorporated in this Act—viz.

(*a*) The Act of 1847, except the provisions relative to the amount of profit to be received by the water-undertakers when the works are carried on for their benefit, and except certain words in section 44;

(*b*) The Act of 1863;

(*c*) The provisions of the Railways Clauses Consolidation (Scotland) Act, 1845, relating to temporary occupation of lands near a railway during its construction, these provisions applying only in the case of any reservoir, filter, or distributing tank which the L. A. may be authorised to construct, and the works connected therewith. These sections are 25 to 37. Provided (1) that the L. A. shall not be obliged to furnish a supply of water to any person for any less sum than five shillings per annum; (2) that no person shall be entitled to demand such supply of water or to require the L. A. to lay down communication-pipes, unless some pipe of the L. A. shall have been laid within 100 feet of the place for which the water is demanded; and (3) that the water to be supplied by the L. A. need not be constantly laid on under pressure.

Section 144. Empowers a L. A. to purchase any lands within or without their district, and by agreement to take on lease, sell, or exchange any lands within or without their district; and to buy up any water-mill, dam, or weir which interferes with the proper supply of water to their district.

II. Burgh Police (Scotland) Act, 1892; Sects. 257 to 269 inclusive.

Burgh Commissioners may maintain existing, and may provide new, wells, etc., for gratuitous supply of water to inhabitants, and may provide water to public baths and wash-houses.

Section 257. Empowers Burgh Commissioners to cause all existing public cisterns, pumps, wells, conduits, fountains and other waterworks used for the gratuitous supply of water to the inhabitants within the burgh, unless the water therein be found to be dangerous or injurious to health or unfit for dietetic purposes, to be contained, maintained, and supplied with water, or to substitute other such works equally convenient, and to cause the substituted works to be so maintained and supplied. Such works shall be vested in the Commissioners and be under their management and control. The Commissioners may construct and maintain any number of new cisterns, pumps, etc., for the gratuitous use of any persons who choose to carry away the water for their own private use, but not for sale, and may supply with water any public baths or wash-houses.

Commissioners may contract for supply of water.

Section 258. Commissioners may contract for any period not exceeding three years at one time, with owners of any waterworks, or with any other person, for such supply of water as they may think necessary for the purposes of this Act.

Arbitration.

Section 259. Determines that in case of failure of agreement between Commissioners and such owners of waterworks as to terms and price of supply, that the terms and price shall be settled by arbitration.

Fire-cocks to be placed on water-pipes for purposes of fire-extinction.

Section 260. Makes it lawful for Commissioners, at the sight of the water engineer of any water-company established or to be established within a burgh or any company or corporation actually supplying water within the burgh, to place proper fire-cocks upon the pipes at such convenient distances from each other and at such places as may be considered proper for the supply of fire-engines when brought into operation, the positions to be arranged by the Commissioners with the directors of the water-company. In case of difference of opinion, such difference shall be determined by the Sheriff whose judgment shall be final.

Commissioners may provide Burgh with water-supply sufficient to maintain a constant flow of water requisite for health of inhabitants and amenity of Burgh. A waterworks Company may contract with Burgh for such supply or may dispose of same to Commissioners. Commissioners not to establish Waterworks within limits of supply of an existing Water-Company without written notice to such Company; nor shall it be lawful for Commissioners to construct waterworks within such limits if and so long as such Water-Company is able and willing to supply sufficient water for needs of the Burgh.

Section 261. Commissioners *may* provide a burgh with such supply of water as may be sufficient and proper for the purposes of this Act, and may maintain such a constant flow of water by means of reservoirs or otherwise as may be requisite for the health of the inhabitants or the amenity of the burgh, and for private use to the extent required by this Act. For this purpose they may contract with any person whomsoever, or purchase, take on lease, hire, construct, lay down, and maintain such reservoirs and waterworks, and do and execute all such works, matters, and things as shall be necessary and proper, including the opening of streets, public or private, from time to time, for the purpose of laying down, altering, or repairing pipes therein. Any waterworks company or owners or lessees of reservoirs may contract to supply water for the purposes of this Act in any manner whatsoever, or may sell and dispose of or lease their reservoirs and waterworks to the Commissioners. And the Commissioners may provide and keep in any waterworks constructed or laid down by them under the powers of this Act, a supply of pure and wholesome water, and the water so supplied may be constantly laid on at such a pressure as will carry the same to the top storey of the highest dwelling-house within the burgh. And the Commissioners by means of such reservoirs and waterworks, or either of them, may maintain such a constant flow of water as may be requisite for the health of the inhabitants or the amenity of the burgh.

Provided always that before constructing or laying down any waterworks under the powers of this Act, within any limits within, or, in respect of which any waterworks company or water commissioners shall have been established for supplying water, the Commissioners shall give notice in writing to every waterworks company, etc. And it shall not be lawful for the Commissioners to construct or lay down any waterworks within such limits, if and so long as any such company shall be able and willing to lay on water, proper and sufficient for all reasonable purposes for which it is required by the Commissioners. In case of differences arising between parties, the same shall be settled by the Sheriff upon summary application by either of the parties, and the decision of the Sheriff shall be final.

Burghs under 5000 inhabitants may ask Sheriff to put in force Lands Clauses Acts for a supply of water.

Section 262. Any burgh having less than 5000 inhabitants at the date of last census, if the Commissioners resolve that in order to obtain a supply of water for the burgh it is necessary for them to acquire land otherwise than by agreement, may, instead of proceeding under the Public Health Acts, present a petition to the Sheriff to obtain his authority to put in force the provisions of the Lands Clauses Acts.

Section 263. Enacts that service-pipes shall be laid by owners of houses.

Service pipes to be laid by owners of houses.

Section 264. No person shall be entitled, without special agreement with the Commissioners, to use the water supplied through the pipes of the Commissioners, except for domestic and ordinary purposes; but where there is a supply more than is required for such domestic and ordinary use within the burgh, it shall be lawful for the Commissioners to contract with any person within the burgh to supply any public baths and wash-houses, works, manufactories, or other premises within the burgh with water at such rate and upon such terms and conditions as may be agreed on. Differences to be settled summarily and determined by the Sheriff.

It shall be further lawful, in the case where the Commissioners have a surplus of water, for them to supply to Commissioners or trustees of any harbour, water for the purposes of supplying ships within the harbour, and for the purpose of extinction of fires on board ship.

Prohibits use of water except for domestic and ordinary purposes. If there be a surplus supply, Commissioners may supply public baths and wash-houses and public works, and ships with water.

Section 265. Enacts that a supply of water for domestic and ordinary purposes shall not include a supply of water for cattle or for horses or for washing carriages or for steam engines or for railway purposes or for warming or ventilating purposes in public buildings or for working any machine or apparatus or for any trade, manufacture, or business whatsoever, or for watering gardens by means of any tap, tube, or pipe, or other such-like apparatus, or for fountains, or for flushing sewers or drains, or for public baths or wash-houses, or for any ornamental purpose whatsoever.

Declares what is a supply of water outside of a supply for domestic and ordinary purposes.

Section 266. Enacts that Commissioners may erect and maintain in any street or public place any ornamental drinking fountain or trough.

Commissioners may erect and maintain public fountains or troughs.

Section 267. Incorporates all the clauses and provisions of the Waterworks Clauses Acts, 1847 and 1863, and any Act amending the same, with respect to the following matters—viz.

(1) Construction of waterworks;
(2) Laying of communication-pipes by inhabitants;
(3) Waste or misuse of water;
(4) Provision against fouling of water;
(5) Payment and recovery of rates.

Incorporates Waterworks Clauses Acts, 1847 and 1863, and any Act amending the same.

Section 268. Empowers burgh Commissioners to make bye-laws regulating all or any matters or things whatsoever connected with the water to be supplied within the burgh through their pipes.

Commissioners empowered to make Bye-laws relative to water-supply.

Section 269. Enacts that the provisions of this Act in respect to supply of water shall not apply in the case of any burgh which is or may be before 31st December 1894 supplied with water under the powers of any local Act or Acts.

Water Clauses of this Act not to apply to Burghs having private Water Acts.

III. Burgh Sewerage, Drainage and Water-Supply (Scotland) Act, 1901 (1 Edw. VII., ch. 24).

This Act was passed owing to the following facts:—Under the Public Health Scotland) Act, 1867, Burgh Authorities could proceed to construct waterworks and assess for the same either under that Act or the Burgh Police Act; but after the Public Health Act of 1897 was passed, complications arose regarding he assessment owing to water-supply works in burghs being no longer authorsed under that Act. The above Act was, therefore, passed to meet this. n the above Act, provision is made for water-assessment and sewer-assessment. The water-assessment takes the place in Burghs (1) of the Burgh general assessment under the Burgh Police Act, 1892, so far as that was applicable to water, and (2) of the water-assessment under the Public Health Act, 1897.

The rights, powers, and privileges of a Local Authority with reference to ewerage, drainage, and water-supply conferred by the Public Health Act of 897 on Local Authorities other than Burgh Local Authorities are restored to the atter, with the exception of the provisions in the Public Health Act of 1897 or the formation of special water and drainage districts as contained in sections

122 and 131 respectively of that Act. These sections as regards drainage shall not apply to Burghs in view of the powers conferred upon Burgh Local Authorities by section 218 of the Burgh Police Act of 1892, and as regards water, special water districts are expressly abolished by section 3 of the above Act of 1901.

Under section 147 of the Public Health Act, 1897, the Local Government Board are empowered to take steps, if necessary, to compel a defaulting Local Authority to perform their duties under that Act or " otherwise by law required of them." To strengthen the hands of the Local Government Board in administering the law with reference to Burghs in the same way, section 147 was amended by this Act of 1901 so as to include Burghs within its scope in administering the provisions of the Burgh Police Act of 1892 ; the effect being that the Board have now the power of compelling Burgh Local Authorities, by summary petition, to provide water and drainage, as the Board had under section 147 in the case of district Local Authorities or County Councils.

Ireland

The law is embodied in the Public Health (Ireland) Act, 1879, *Sections* 61 *to* 79 *inclusive*, with certain sections from the Lands Clauses Acts, as amended by the provisions of the Working Classes Act, 1890, Second Schedule.

Generally speaking, Irish law relating to water-supply on main lines differs in nothing essential with respect to *powers*, but not a little in respect of *procedure* from the English Act.

Under the section dealing with " power to purchase lands," the Act for Ireland confers upon every Sanitary Authority power to acquire compulsorily sources of water and water way-leaves, since the term " land " includes " any land covered with water, or any water, or right to take or convey water." By Provisional Order, also, compulsory powers may be granted by the L. G. B. for the purchase of water-sources for water for drinking and domestic purposes.

With respect to the purchase and procuring of land, *other than by agreement*, procedure is simplified by section 8 which enacts that the provisions of the Lands Clauses Acts shall be amended by the provisions of the Working Classes Act, 1890, second schedule ; so that, when plans for a proposed water-supply have been lodged with the Local Government Board, an arbiter shall be appointed by the Board, who shall hear and examine claims, and, thereafter, shall make his award, which is final.

Examination of Water as to Purity.—The complete examination of a water involves different lines of inquiry—viz.

(*a*) Physical characters ;
(*b*) Chemical characters ;
(*c*) Biological or bacteriological characters.

(A) The physical examination includes (*a*) the presence or absence of suspended matters ; (*b*) colour ; (*c*) taste ; (*d*) odour ; (*e*) amount of dissolved gases.

Suspended matters may be discovered by holding a clear glass vessel containing the water between the eye and a good light. To establish their character, they should be allowed to subside in a conical-shaped vessel, pipetted off, and examined microscopically by dotting a series of slides with the deposit. They may consist of (*a*) mineral matters ; (*b*) vegetable débris or algæ ; (*c*) animal débris. The amount per gallon may be estimated by filtering a given quantity of water through a tared filter, drying, and weighing, and the amounts of mineral and organic matter respectively by igniting the deposit and filter-paper, the difference in weight, minus the ash of filter-paper, being the amount of organic matter, the remainder being the mineral.

Colour is best compared against an equal column of distilled water. For this purpose, equal quantities of the water and distilled water are put in 2 feet long tubes with ground-glass bottoms, and the observer looks down the columns of water which are held close together against a white surface. By this means very slight differences may be detected. All potable waters have some measure of colour compared with distilled water. They vary from bluish to yellowish or brown; the former in chalky, the latter in peaty, waters. A greenish hue is, upon rare occasions, observed in waters, the sources of which are infested with pond-weed, and is due to chlorophyll. Water of a reddish tint betokens iron, which is corroborated by the deposit of the reddish-yellow oxide on the sides and bottom of the original vessel, and at the source.

Taste.—Good, well-aerated water is palatable, does not possess any distinct taste, but does possess something which the sense of taste distinguishes at once from a "boiled" water. Palatability may be possessed, however, by an impure water. This palatability seems to depend largely upon the contained atmospheric gases. Actual taste may be imparted to a water by contamination by odorous substances, or by the presence of excess of mineral salts. Short of mineral waters which possess distinct taste, potable waters may possess an unusual amount of mineral salts. Iron existent in quantity to one-fifth grain per gallon imparts a taste; lime salts, when in quantities of 10 to 25 grains; and sodium chloride, of 75 grains. The presence of certain vegetable organisms, as *Crenothrix*, imparts a bitter taste.

Odour.—Good water has no smell. Certain mineral waters containing sulphur gases possess a disagreeable odour due to H_2S. Ordinary potable water seldom possesses any odour, except when much polluted by fæcal matter, by coal-gas, or by other odorous substances, as paraffin products. We have detected both of these last in waters analysed by us. The most efficient way to detect odour is to warm the water in a corked flask, and then by sniffing on removal of the stopper. No water is potable which has a perceptible odour.

Amount of dissolved gases.—This investigation is carried out by special apparatus. A well-aerated water contains atmospheric gases to the extent of 20·73 c.c. volumes per litre. The gas which in polluted water shows reduction is oxygen.

(B) CHEMICAL EXAMINATION.—For sanitary purposes this resolves itself into examination for (*a*) mineral constituents; (*b*) hardness; (*c*) chlorides; (*d*) ammonia, free and albuminoid; (*e*) nitrates and nitrites; (*f*) organic matter.

Mineral Constituents.

(*a*) LIME—*Quantitative.*—A definite quantity of water being taken (250 c.c.), ammonia and powdered crystals of ammonium oxalate are added by stirring. After some hours, the precipitate is filtered, washed, dried, weighed, and ignited, and the residue weighed as calcium carbonate. The amount found, counted as milligrammes and multiplied by 4, will give parts per million.

Qualitative. The reagents are the same. They will give a distinct turbidity when lime is present to the extent of 8 parts per 100,000 or 5 grains per gallon.

(*b*) MAGNESIA—*Quantitative.*—The filtrate from the lime estimation may be concentrated by boiling, after which sodium phosphate, ammonium chloride, and excess of ammonia are added, and the solution freely stirred. After standing for 24 hours, the crystalline ppt. of ammonium-magnesium-phosphate (NH_4MgPO_4) is filtered, the ppt. washed with ammonia and water from a wash-bottle, then dried, ignited, and the residue weighed as magnesium pyrophosphate $(MgO_2)\ P_2O_5$. The triple phosphate being soluble to some extent in water, it is customary to add 1 milligramme for every 50 c.c. of washings.

Qualitative,—The reagents are the same.

(*c*) IRON—*Quantitative.*—This is best estimated colorimetrically. Reagents necessary: (1) A standard solution, made up of 4·96 grammes of ferrous-sulphate per litre, of which 1 c.c. is equivalent to 1 milligramme of iron; (2) Solution of potassium sulphocyanide, 5 grammes in 100 c.c. distilled water; (3) Nitric acid, 30 c.c. strong acid to 100 c.c. distilled water. Into Nessler glasses place an equal quantity of (*a*) water-sample, and (*b*) distilled water respectively; to (*a*) add 5 c.c. of nitric acid solution, to oxidise ferrous into ferric iron, and then add 15 c.c. of solution of potassium sulphocyanide. If iron be present, a beautiful rose colour will develop. Into the glass (*b*) put one or more c.c. of the standard iron solution, with equal quantities of the other reagents as in (*a*), until the colours are exactly matched; that is, until they contain equal quantities of iron. Since it is known what amount has been added, calculation will show amount present per 100,000 parts of water.

Qualitative.—Ammonium sulphide causes the water to become of a darker colour, due to iron sulphide, but this disappears on addition of some drops of dilute HCl.

(*d*) LEAD—*Quantitative.*—This may be estimated colorimetrically. Reagents necessary: (1) A standard solution of lead nitrate or acetate, made by dissolving 1·6 of nitrate or 0·1831 grammes of acetate per litre of freshly distilled water, of which 1 c.c. is equivalent to one milligramme of lead; (2) Clear sulphuretted hydrogen water. Equal quantities of water-sample and distilled water are placed in Nessler glasses, and 1 c.c. of H_2S water added to sample. If lead be present the water will become darkened (seen by looking through column of water against a white ground). This colour must be matched in the other glass by adding sufficient standard lead solution, but the same amount only of the other reagent as in the former glass. Calculation will bring out parts per 100,000 or in any other proportion.

Qualitative.—H_2S gives the same reaction qualitatively, the colour being unchanged on addition of dilute HCl, but the chloride is thrown down, which dissolves on boiling the mixture. Solution of chromate or iodide of potassium gives a faint yellow turbidity in presence of minute quantities of lead.

(*e*) COPPER—*Qualitative.*—This is a rare constituent of natural waters. If suspected, however, a few drops of ammonium sulphide should be added. If, on addition of dilute HCl, the dark colour does not disappear, it may be due to either lead or copper. To a fresh part of water, and after addition of NH_4HS, add solution of potassium cyanide; if copper, the dark colour will disappear.

Quantitative.—If copper be found qualitatively, it may be estimated quantitatively as for iron or lead, by using a standard solution of copper sulphate made by dissolving 3·93 grammes of that salt per litre of water, of which 1 c.c. is equivalent to 1 milligramme of copper.

(*f*) *Zinc.*—Is sometimes found in waters after standing for some time in galvanised vessels, or in those collected from zinc-galvanised roofs. Such have been recorded from Llanelly, Wales, the Malay Peninsula, and other places. In the latter-named place, the quantity of zinc found amounted to 1·115 parts per 100,000, and in the former to about 70 parts per 100,000. Add nitric acid; boil; filter. To filtrate add potassium *ferrocyanide* solution, when, if zinc is present, a haze or turbidity will develop.

(*g*) SULPHATES (as SULPHURIC ACID). Such are found in hard waters in combination with lime and magnesia.

Qualitative.—If to a sample of water, on addition of dilute HCl and a solution of barium chloride, a white haze or turbidity or ppt. appears, the presence of sulphates is indicated. This test will detect 2 to 3 grains per gallon, or 4 parts per 100,000.

Quantitative.—If the same reagents in excess be added to 250 c.c. of sample with free stirring, and the ppt. allowed to settle, then filtered, washed, dried, ignited, and weighed, the amount in parts per 100,000 may be calculated from the weight of the $BaSO_4$.

(*h*) SULPHIDES (as H_2S)—*Qualitative.*—(1) A solution of lead acetate gives a darkened colour to the column of water of PbS ;

(2) A solution of copper sulphate gives a like result of CuS ;

(3) If a few drops of dilute caustic soda (NaHO) be added to water-sample, followed by an equal quantity of a solution of nitro-prusside of sodium a violet coloration is produced. This test detects minute quantities.

(*i*) CHLORIDES (as CHLORINE).—The purity of waters being in some degree estimated from the quantity of chlorides found, this test is of importance.

Qualitative.—If on addition to the water-sample of dilute nitric acid and a solution of silver nitrate a haze, turbidity, or ppt. result, chlorides are present. One grain per gallon gives a decided haze, four grains, marked turbidity ; or 1·5 and 5·7 parts per 100,000, respectively.

Quantitative.—Solutions necessary : (1) A standard solution of silver nitrate, made by dissolving 4·588 grammes of that salt per litre of distilled water, of which 1 c.c. is equivalent to 1 mgrm. of *Chlorine* ; (2) A saturated solution of potassium chromate, made chlorine-free by addition of silver nitrate until a ppt. of silver chromate is permanently formed. On decanting the clear yellow solution, it is ready for use. 100 c.c. of water-sample are placed in a wide-mouthed flask standing on a white surface, two drops of potassium chromate solution are added, and from a burette the standard silver solution is added slowly in drops, with continuous rotatory movement of the flask, until the silver chromate ceases to be dissolved, and a faint *reddish* tinge is imparted to the fluid in the flask. The number of c.c. of silver solution used equals the parts per 100,000 of the chlorine present. By multiplying the figure found by 0·7, the equivalent in terms of grains per gallon is found.

(*j*) NITRATES—*Qualitative.*—*a.* To water-sample in test tube add some strong H_2SO_4, and a few drops of a solution of *diphenylamine* in H_2SO_4. If a blue colour be struck, nitrates are present.

b. Evaporate to dryness in porcelain capsule 25 c.c. of sample ; add two drops of strong H_2SO_4, and a granule of brucine, and a rose colour, becoming rain-bow like, will appear. This test detects one part in a million of water.

Quantitative.—Reagents necessary : (1) Solution of phenolsulphonic acid, made by dissolving together 6 grammes pure carbolic acid, 37 c.c. strong H_2SO_4, and 3 c.c. distilled water ; (2) Standard solution of potassium nitrate, made by dissolving 0·722 gramme of the pure fused salt per litre of distilled water, of which 1 c.c. is equivalent to 0·1 mgrm. of *nitrogen.*

Process.—Evaporate to dryness 10 c.c. or more of the sample ; add 1 c.c. of phenolsulphonic acid ; mix residue with glass rod, then add 1 c.c. distilled water, and 3 drops of strong sulphuric acid ; warm on water-bath ; then add 25 c.c. distilled water. Put solution in a Nessler glass, and fill up to zero-mark with dilute clear caustic potash solution. The yellow colour present is due to potassium picrate.

Treat 1 c.c. or 2 c.c. or more of the standard nitrate solution in exactly the same way, and compare the colours produced. When the colours are matched, calculation from the quantity of standard nitrate added to the parallel test-glass will show the parts of nitrogen present per 100,000 parts of water.

(*k*) NITRITES—*Qualitative*—*a.* If a solution of zinc iodide starch solution and dilute H_2SO_4 be added to sample, and a blue coloration develop (best seen by looking through water column against white ground), nitrites are present, according to the equation—

$$ZnI_2 + 2KNO_2 + 2H_2SO_4 = I_2 + ZnSO_4 + K_2SO_4 + 2NO + 2H_2O.$$

On addition of the acid, nitrous acid is liberated from its combination, which in turn dissociates the iodine from the zinc, and renders it free. The free iodine unites with the starch to form the blue iodide of starch. This test can detect one part in fifty millions of water.

b. On addition of the acetic acid solution of sulphanilic acid and naphthylamine acetate solution, a beautiful pink colour appears, but only slowly if quantity of nitrites be small.

Quantitative.—Reagents required : (1) Solution of sulphanilic acid, made by dissolving 0·5 gramme of the acid in 150 c.c. of dilute acetic acid (sp. gr. 1040); (2) Solution of naphthylamine acetate, made by boiling 0·1 gramme of solid naphthylamine in 20 c.c. distilled water, filtering through a plug of washed cotton-wool, and mixing filtrate with 180 c.c. of dilute acetic acid (as above) ; (3) Standard solution of sodium nitrite, made by dissolving 0·275 gramme of pure silver nitrate in distilled water, and then adding a dilute solution of pure sodium chloride until the ppt. of silver chloride ceases to fall. Add up to 250 c.c. with distilled water. The solution contains per c.c. 0·1 mgrm. of nitrogen as sodium nitrite. For use, 10 c.c. of this solution are diluted to 100 c.c. with distilled water, and 1 c.c. of this now contains 0·01 mgrm. of nitrogen. These solutions must be kept in the dark when not in use, and in dark glass bottles.

Process.—25 c.c. or 50 c.c. of sample are placed in a Nessler glass, and to it are successively added 2 c.c. of solutions (1) and (2) by means of different pipettes. The pink colour which appears must be exactly matched. Into another Nessler glass are placed an equal quantity of distilled water, 1 or more c.c. of the standard nitrite solution (3), and quantities of the reagents similar to those in the other glass. When the colours are matched, the number of parts of nitrogen as nitrites per 100,000 parts of sample may be calculated from the data which have been found.

(*l*) COMBINED NITROGEN IN NITRATES AND NITRITES, ETC. The total quantity of nitrogen, as nitrates and nitrites, may be estimated by the copper-zinc couple process. Zinc foil is coated black with copper by galvanic action on being placed in a solution of copper sulphate containing 1·8 per cent., and is then carefully washed with distilled water. The couple, as it is then called, is put into a wide-mouthed glass-stoppered bottle with 250 c.c. of the water-sample, to which has been added 0·5 gramme of finely powdered oxalic acid. The bottle, stoppered, is placed in a warm place for twenty-four hours. The couple acts by electrolysis on the water, liberating hydrogen and splitting up the combined nitrogen ; and these uniting together form ammonia, which is estimated by direct Nesslerising (*q.v.*) after filtering, to rid the water of any lime oxalate which may have been precipitated. The combined nitrogen is, thereafter, estimated by this process in terms of ammonia.

(*m*) PHOSPHATES—*Qualitative.*—Add some dilute HNO_3 to 250 c.c. water-sample, and evaporate to dryness. Heat residue cautiously, dissolve in dilute HNO_3, and filter. To clear filtrate, add twice the volume of warmed, strong solution of ammonium molybdate. The formation of a yellow colour or turbidity indicates phosphates, as ammonium phospho-molybdate.

Since it is but the very rarest occurrence that phosphates are present in more than traces, quantitative examination is usually unnecessary.

(*n*) HARDNESS—*a.* Soap Method.

Quantitative—Reagents required : (1) Standard soap-solution, made by dissolving 10 grammes of finely-powdered Castile soap in a litre of 35 per cent. alcohol ; (2) Standard solution of lime, made by dissolving 1·11 grammes of pure calcium chloride in a litre of distilled water, of which 1 c.c. is equivalent to 1 milligramme of $CaCO_3$. It is necessary to standardise the soap-solution against standard lime solution, so that 1 c.c. of it will be equal to 1 c.c. of the other. To do this, 5 c.c. or 10 c.c. of the standard lime solution should be diluted to 100 c.c. with distilled water, put into a glass-stoppered bottle, and the standard soap solution from a burette added in small quantities at a time, with vigorous shaking of bottle and contents after each addition, until a uniform, creamy lather is formed which will remain unbroken for 5 minutes when the bottle is laid on its side. If the number of c.c. of soap solution added be 6·5—where 5 c.c. of standard lime solution has been used—or 11·5 where 10 c.c., then the soap solution is right, since 1·5 c.c. of it are required for the distilled water alone. If, however, less be necessary, then it is too strong, and it must be diluted with the necessary amount of weak alcohol, the precise number of c.c. to be added being calculated from the mean of three titrations. As soap solution decomposes on keeping, it is necessary to titrate it against the standard lime solution from time to time, so as to know its valency.

Let it be assumed that 1 c.c. of the soap solution is equal to 1 c.c. of the standard lime solution, then the process of testing the water-sample is as follows:—

In a glass-stoppered bottle put 100 c.c. of water-sample; from a burette, add the soap solution in quantities of 1 c.c. at a time, shake vigorously after each addition, until a lather of the kind and persistency described above is formed. Repeat the process a second time, adding the soap solution more boldly till the lathering point is neared, and then only drop by drop, for exact estimation. The number of c.c. of soap solution used by 100 c.c. of water-sample, less 1·5 c.c., is the measure of hardness in terms of $CaCO_3$ per 100,000 parts. Thus: Suppose 12·5 c.c. of soap-solution are used by 100 c.c. of water (1 c.c. = 1000 milligrammes), then 12·5 − 1·5 c.c. = 11 parts of $CaCO_3$ per 100,000 parts of water.

The foregoing estimation is of the *total hardness*. To estimate the *temporary* hardness, 100 c.c. of sample are boiled for twenty minutes in a flask and then filtered, and the quantity less than 100 c.c. lost by evaporation is made up to that figure by the addition of distilled water. Since boiling drives off CO_2 and thereby throws down the carbonates of lime and magnesia, the hardness due to these salts is now removed. Titration of the water, performed as above, now gives the permanent hardness. Suppose 6·0 c.c. of soap solution were now required, then 6 − 1·5 = 4·5 = parts of *permanent* hardness per 100,000. To ascertain the *temporary* hardness, it is only necessary to deduct the figure for the permanent hardness from that of the gross total hardness, and 1·5 from the remainder, thus:—

$$(12{\cdot}5 - 4{\cdot}5) - 1{\cdot}5 = \underline{6{\cdot}5}$$ temporary hardness per 100,000 parts of sample.

b. Chemical Method.

Reagents required: (1) $\frac{N}{50}$ solution of pure sodium carbonate, made by dissolving 1·06 grammes of the pure salt in one litre of distilled water, of which 1 c.c. contains ·00106 gramme Na_2CO_3, and is equivalent to ·001 gramme or 1 mgrm. of $CaCO_3$; (2) $\frac{N}{50}$ solution of sulphuric acid, of which 1 c.c. is equivalent to 1 c.c. of $\frac{N}{50}$ Na_2CO_3; (3) Solution of methyl-orange (as indicator).

Process—a. Temporary hardness.—To 250 c.c. of water-sample add two drops of indicator, and heat to boiling. From burette, filled with $\frac{N}{50}$ H_2SO_4, add drop by drop (shaking flask constantly) until yellow colour changes to pink. Since each c.c. of $\frac{N}{50}$ acid used is equivalent to 1 mgrm. of $CaCO_3$ from the number of c.c. used, the quantity of $CaCO_3$ present may be calculated.

b. Permanent Hardness.—To 100 c.c. of sample add slight excess of $\frac{N}{50}$ of Na_2CO_3 (usually equal parts will be sufficient); evaporate mixture to dryness in platinum vessel; extract residue with distilled water; filter solution through small filter-paper and wash well the deposit on filter with hot distilled water; titrate combined filtrate and washings with $\frac{N}{50}$ acid after addition of two drops of indicator. The difference in number of c.c. of $\frac{N}{50}$ Na_2CO_3 originally added to sample and the number of c.c. of $\frac{N}{50}$ acid required to neutralise the solution equals the measure of the permanent hardness in amount of sample treated. By easy calculation, the amount in parts per 100,000 of permanent hardness, in terms of $CaCO_3$, may be found.

Rationale.—The addition of the $\frac{N}{50}$ alkali to sample decomposes sulphates, chlorides, and nitrates of lime and magnesia, and liberates the corresponding acids by forming carbonates with the bases which were combined with the acids named.

Note.—If the original sample be alkaline from presence of Na_2CO_3, K_2CO_3, or both, there will be no permanent hardness, and if titration has been carefully performed, more $\frac{N}{50}$ acid will be required in titration of filtrate than the amount of $\frac{N}{50}$ alkali added initially to water-sample. The difference in excess equals the amount of alkaline carbonates natively present in water-sample. In such a case, therefore, to obtain the true temporary hardness it is necessary to deduct the excess in this process from the result obtained in the estimation of temporary hardness.

(*o*) AMMONIA—*Qualitative.*—If two or three drops of Nessler's solution be added to a column of water in a Nessler glass or long test-tube, and a yellow or yellowish-brown colour be formed, ammonia is indicated. This test detects minute quantities.

Quantitative (Wanklyn's Process).—Reagents required: (1) Standard solution of ammonium chloride, made by dissolving 0·382 gramme of pure dry ammonium chloride in a litre of distilled, ammonia-free water, of which 1 c.c. is equivalent to 0·1 mgrm. of ammonia; (2) A weaker standard solution, made by making up 100 c.c. of the above to one litre with distilled, ammonia-free water, of which 1 c.c. is equivalent to 0·01 mgrm. of ammonia; (3) Nessler's reagent, made by dissolving 15 grammes of potassium iodide, 17 grammes of mercuric chloride, and 160 grammes of caustic potash in a litre of distilled, ammonia-free water. If a permanent precipitate be not formed, sufficient mercuric chloride solution (saturated) must be added until it is formed. The reagent is then sensitive for use; (4) Alkaline permanganate solution, made by dissolving 8 grammes of potassium permanganate and 200 grammes of solid caustic potash in a litre of distilled water. After solution of ingredients, the mixture should be boiled until one-third of the bulk is evaporated. After the mixture is cooled, the total bulk is made up to one litre by the addition of ammonia-free water, which ensures the freedom of the reagent from ammonia; (5) Distilled ammonia-free water.

The ammonia in a water is estimated as *Free* or *Saline* and as *Albuminoid* ammonia, the latter being a measure of the nitrogen contained in more or less complex albuminoid compounds in a water, and which is converted into ammonia by the action of the alkaline permanganate solution.

The estimation of the ammonia in this process is colorimetric, and is made in the distillates obtained from the water by distillation, the process of colorimetric estimation being known as "Nesslerising."

The following apparatus is required: (*a*) A boiling flask; (*b*) A Liebig's condenser, fitted with an adapter; (*c*) 1 c.c. and 2 c.c. pipettes; (*d*) Nessler glasses, graduated at 50 c.c. and 100 c.c., or Hehner's glasses, graduated in ½ and 1 c.c. up to 100 c.c., and fitted with glass stop-cock; (*e*) Capillary glass tubes.

FREE OR SALINE AMMONIA—*Process.*—Half a litre of water-sample is placed in the cleaned boiling-flask, a pinch of freshly-ignited sodium carbonate (to make the water decidedly alkaline) is added, the flask is connected tightly with the Liebig's condenser, and the contents of the flask are heated to brisk boiling by a Bunsen burner. The distillate is collected in Nessler glasses, 50 c.c. or 100 c.c. at a time, until 300 c.c. have been distilled over. These distillates are reserved for Nesslerising. They contain the *Free* or *Saline* Ammonia.

ALBUMINOID AMMONIA.—To the 300 c.c. of water left in the boiling-flask are added 50 c.c. of the alkaline permanganate solution, and, in order to prevent "bumping" of flask and contents during subsequent boiling, some glass capillary tubes sealed at one end in the flame. The apparatus is again connected, and boiling resumed until 200 c.c. are distilled over, in which is contained the *albuminoid* ammonia. This, like the former distillate, is collected in 50 c.c. or 100 c.c. Nessler glasses for Nesslerising.

Nesslerising—Free Ammonia.—A Nessler glass containing the first distillate of 100 c.c. is placed on a large, white porcelain tile. To it are added 2 c.c. of Nessler solution by means of a pipette, and the whole is stirred by a clean glass rod. After 5 minutes the colour produced is observed, as the object is to match exactly the colour in another like-sized Nessler glass. Into a second glass, therefore, is pipetted 1 c.c., 2 c.c. or more of the weak standard ammonia solution (2), the glass filled up to the 100 c.c. mark with ammonia-free water (5), and 2 c.c. of Nessler reagent added by pipette. If the quantities of ammonia in each glass be similar in amount, the colours produced will be identical; if not, then the colour of one or the other will be darker, depending upon which contains the larger quantity of ammonia; in which case, the object being to match the colour of the distillate, smaller or larger quantities of the weak standard ammonia must be made up with fresh ammonia-free water until the colours are exactly matched. When that is attained, it is known that the quantity of ammonia present in the distillate is equal to that added in the parallel glass.

The second 100 c.c. of distillate is Nesslerised in the same way, and the sum of the two is the amount of Free Ammonia in 500 c.c. of water-sample.

The distillate containing the albuminoid ammonia is then similarly dealt with and the amount of ammonia estimated in like manner.

Example.—Colours were matched in first 100 c.c. of distillate of *free* ammonia by 2 c.c. of standard ammonia solution (*b*), of which 1 c.c. $=\cdot01$ mgrm. ammonia; and in second 100 c.c. by 1 c.c.; therefore $\cdot01\times2+\cdot01\times1=\cdot03$ mgrms. of ammonia in 500 c.c., or 500,000 mgrms. of water; or $\cdot03\times2=\cdot06$ in 1000 c.c. or 1,000,000 parts; or ·006 parts per 100,000 of water.

Albuminoid Ammonia.—Colours were matched in first 100 c.c. of distillate by 5 c.c. of ammonia solution; and in second 100 c.c. by 3 c.c.; therefore $\cdot01\times5+\cdot01\times3=\cdot08$ parts in 500 c.c. of water; or $\cdot08\times2=\cdot16$ parts in 1000 c.c., or 1,000,000 parts; or ·016 in 100,000 parts.

In Nesslerising it is not a good plan to make additions of standard ammonia solution, to bring up the colour, after Nessler reagent has once been added, as the column becomes muddy and the colour difficult of comparison. It should also be noted that on rare occasions the colour in the distillate produced is difficult to compare, for reasons that are not well known. *It is very important that the water to be distilled should be alkaline, since acid waters will not give up their ammonia.*

To overcome the trouble of mixing different solutions to get the exact one to match the colours in the distillates, Hehner's glasses were devised. Suppose that the Nesslerising is done in two of such glasses, and that in one or other the colour is either darker or lighter, it is only necessary to run off the fluid from the darker until the colour is alike to that of the other. If, for example, the distillate be run down to 70 c.c. from 100 c.c. before the colours are equal, and if 2 c.c. of standard ammonia (2) have been added to the parallel glass, then obviously the quantity of ammonia in 100 c.c. of distillate is greater than in the other in the proportion of 70 to 100; therefore, $\cdot01\times2\times\frac{10}{7}=\cdot0286$ mgrms. will be the quantity present in 100 c.c. of distillate. If, on the other hand, the colour in the parallel glass into which 2 c.c. of standard ammonia had been put was the darker, and that it had to be run down to 80 c.c. when the colours became equal; then, obviously, the quantity of ammonia present in the distillate will be less than it originally contained in the proportion of 100 to 80; therefore, $\cdot01\times2\times\frac{8}{10}=\cdot016$ mgrms. is the amount of ammonia in 100 c.c. of distillate. This method is not only more expeditious, but is equally accurate so long as the liquid column is not run down lower than 50 c.c.

(*p*) ORGANIC MATTER—*Tidy-Forchammer Process.*—The organic matter is estimated in this process in terms of "oxygen consumed" in given periods of time, those commonly employed being twenty minutes and 3 hours respectively.

Quantitative—Reagents required: (1) Standard solution of potassium permanganate, made by dissolving 0·395 gramme of that salt in a litre of freshly-distilled water, of which 10 c.c. is equivalent to 1 milligramme of available oxygen; (2) Solution of sodium thiosulphate, made by dissolving ·5 gramme in a litre of distilled water; (3) Solution of potassium iodide (free from iodate), made by dissolving 10 grammes in 100 c.c. of distilled water; (4) Starch solution, freshly made, composed of a filtered solution in which 10 parts of arrowroot starch have been boiled in 200 parts of water; (5) Dilute sulphuric acid (1 part to 3 of distilled water) which remains slightly pink after addition of a few drops of potassium permanganate and after heating at 80° F., for 4 hours.

Apparatus required: (*a*) Flasks, with a capacity of 400 c.c., four in number; (*b*) Flat, open water-bath; (*c*) Pipettes, 5 c.c. and 10 c.c.; thermometers.

Process.—Into each of two of the flasks put 250 c.c. of the water-sample, and into each of the other two, 250 c.c. of freshly-distilled water. (*Note.*—The flasks must be *chemically clean* before being used.) The four flasks are placed in the water-bath and the temperature regulated so that the water of the flasks during the experiment is uniformly maintained at about 80° F. Into each of the four flasks put 10 c.c. of permanganate solution (1), and 10 c.c. of sulphuric acid (4). Should the pink colour be discharged during the course of the experiment, another 10 c.c. of permanganate must be added; or a third if required, in the case of bad waters. At the end of twenty minutes, two of the flasks are removed from the bath, and to each is added 2 c.c. of potassium iodide solution (3). As is the amount of permanganate unacted upon so is the amount of iodine which is liberated. In consequence of this change, the fluid in the flask which formerly was pink now becomes yellow. From a burette filled with sodium thiosulphate solution, a quantity is added sufficient to nearly discharge this yellow colour; then 2 c.c. of starch solution (4) are added, which strikes a blue or greenish-blue colour with the remaining free iodine; the addition of thiosulphate is then continued until the blue colour is just discharged. The number of c.c. of the thiosulphate used to produce this effect in the flask containing the distilled water is taken as the measure of the oxygen-value of 10 c.c. of standard permanganate—viz. 1 mgrm. of oxygen, and the difference between the number of c.c. used in the distilled water and in the water-sample respectively is the measure of oxygen used up by the organic matter in the water-sample. For example: In twenty minutes, the number of c.c. of thiosulphate required for 250 c.c. of distilled water + 10 c.c. standard permanganate = 45 c.c.; number required for 250 c.c. of water-sample containing 10 c.c. of permanganate = 25 c.c. The former amount is equivalent to 10 c.c. of standard permanganate used, or 1 mgrm. of oxygen; the latter subtracted from the former is the measure of the amount of oxygen consumed in the water-sample. Therefore 45 c.c. − 25 c.c. = 20 c.c. The calculation, then, is as follows: $45 : 20 :: 1 : x \therefore x = \cdot\dot{4}$ mgrm. of oxygen; that is $\cdot\dot{4}$ mgrm. of oxygen has been consumed in 250 c.c. of sample in twenty minutes. Since, however, only 250 c.c., or 250.000 mgrms. of water-sample have been used, the figure $\cdot\dot{4}$ must be multiplied by *four* to bring out parts per million. Therefore $\cdot\dot{4} \times 4 = 1\cdot7$ mgrms. of oxygen consumed per million parts of water, or ·17 parts per 100,000.

The other two flasks, which have been exposed for three hours, are similarly treated, and the result computed in the same way.

The object of the different periods of exposure is to differentiate the nature of the oxidisable matter. The period of twenty minutes indicates the amount of oxygen consumed in the oxidation of chemical salts; that of three hours, the amount consumed in the oxidation of organic bodies of an albuminoid character.

The chemical equations of the different stages of the process are these :—

1. $4KMnO_4 + 6H_2SO_4 = 4MnSO_4 + 2K_2SO_4 + 6H_2O + 5O_2$;
2. $2KMnO_4 + 10KI + 8H_2SO_4 = 2MnSO_4 + 6K_2SO_4 + 8H_2O + 5I_2$;
3. $2Na_2S_2O_3 + I_2 = 2NaI + Na_2S_4O_6$.

By the addition of starch solution the blue or bluish-green iodide of starch is formed, which is discharged by further addition of sodium thiosulphate. (*Vide also* p. 300.)

Opinion of Quality of Water from Chemical Analysis.—This opinion has reference to (1) purity, and (2) economical use. The constituents in a water, with reference to purity, to which close attention must be paid, are : amounts of (*a*) chlorides ; (*b*) of ammonia, free and albuminoid ; (*c*) of nitrates and nitrites ; and (*d*) of oxidisable organic matter. In a water which is much polluted and has been for some time in that condition, abnormally high proportions of all these ingredients will likely be found. The source of the excess of chlorides is urine of sewage, and of ammonia, the decomposition of urea, while the nitrites and nitrates express progressive stages of oxidation of nitrogen from decomposed albuminoid bodies derived from sewage or vegetable albuminoid bodies, and the oxidisable organic matter may be taken as a gauge of the organic matter, liable to decomposition or oxidisation, which is present.

In order to institute comparisons, it is necessary to form a standard from the proportions of these, or some of these constituents which a pure water contains, in order to estimate which waters are impure, and what their relative impurity.

A pure water may be considered as containing the above ingredients in the following proportions, viz. :—

Chlorine	= less than 1·4	parts per	100,000.
Free ammonia	= ·002	,,	,,
Alb. ,,	= ·005	,,	,,
Nitrogen {Nitrites Nitrates}	= ·0025	,,	,,
Oxygen consumed	= less than 0·1	,,	,,

A usable, or second-class water contains—

Chlorine	= less than 5	parts per	100,000.
Free ammonia	= ·005	,,	,,
Alb. ,,	= ·010	,,	,,
Nitrogen {Nitrites Nitrates}	= ·125	,,	,,
Oxygen consumed	= ·15	,,	,,

A suspicious, or third-class water contains—

Chlorine	=	more than	5	parts	per 100,000.	
Free ammonia	=	,,	·005	,,	,,	and less than ·025.
Alb. ,,	=	,,	·010	,,	,,	
Total nitrogen (as above)	=	,,	·12	,,	,,	and less than ·245 parts
Oxygen consumed	=	,,	·15	,,	,,	

An impure, or dangerous water contains—

Chlorine = from 7 to 10 parts per 100,000.
Ammonia $\left\{\begin{matrix}\text{Free}\\ \text{Alb.}\end{matrix}\right\}$ = „ ·0225 to ·025 parts per 100,000.
Nitrogen $\left\{\begin{matrix}\text{Nitrates}\\ \text{Nitrites}\end{matrix}\right\}$ = „ ·260 parts per 100,000 and upwards.
Oxygen consumed = „ ·20 „ „ „ „ „

While it is true that these standards are arbitrary, they may be deemed as fairly accurate and representative of different classes of waters. It is very unsafe to pronounce an opinion unfavourable to the potability of a water from an abnormally high amount of any single ingredient, as, for example, chlorine, albuminoid ammonia, organic matter, or nitrates, for each of these when found alone is compatible with purity.

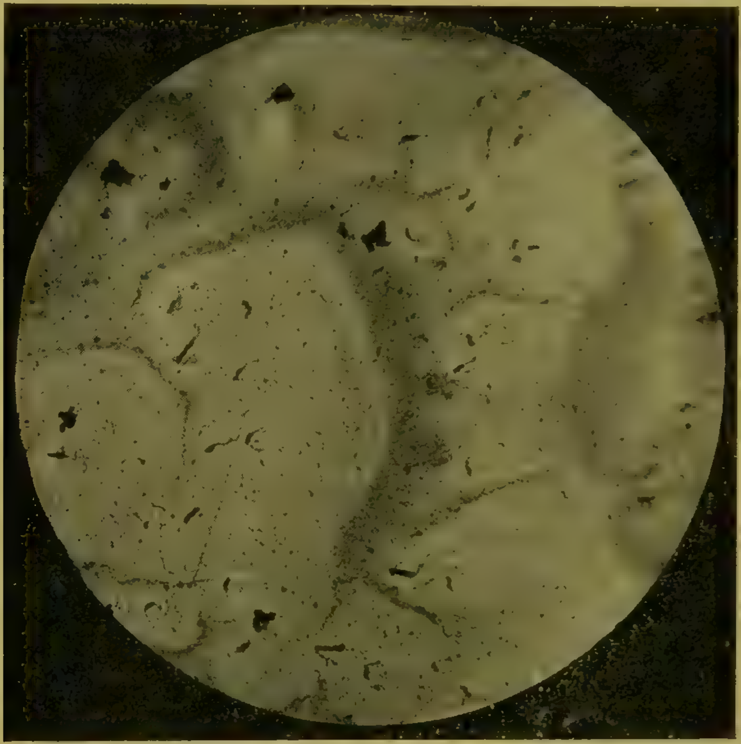

FIG. 49.—Photo-micrograph of *Spirillum rubrum*—a not uncommon water micro-organism. × 500 diameters. (Author.)

For example, while in any water excess of chlorine to the amount of 15 to 18 parts per 100,000 would make the examiner suspicious of pollution, a low total of free and albuminoid ammonia, absence of nitrates, and low "oxygen consumed" would show that the excess of chlorine was due to some uncommon cause, which on inquiry would most likely prove to be proximity to the sea. We have several times had this experience. High albuminoid ammonia is a common feature of upland waters, and if a judgment was formed from this factor alone, it would likely be wide of the true mark, since its presence is accounted for by vegetable, peaty matter. Loch Katrine supply contains ·008 parts per 10,000 of albuminoid ammonia, but it has practically no free ammonia. In the same way, even with excess of chlorides and nitrates in a water, judgment would be liable to err if the fact is not known that such ingredients may be found in the waters of Artesian wells regarding the sewage contamination of which there is no possibility. In forming an opinion upon the potability or purity of a water from chemical analysis only, careful scrutiny and comparison must therefore be made of the different constituents which ordinarily indicate by their presence in excess sewage contamination, and from the relation of these to each other, a tentative opinion only should be offered. Before a definite, final opinion is given, exact information ought to be obtained regarding the source of supply of the water, and of its position and environment with respect to possible pollution.

Opinion as to Economical Use.—From what has been said, a hard water is less profitable and less suitable to a community than a soft water, and for the reasons formerly given. Where a new water-supply is proposed, of two waters, one hard and one soft, which are available, and where both are satisfactorily pure, the latter is preferable. Keeping the object in view for which the water is desired, a hard water may, however, be more useful than a soft water. This is particularly true, for example, of beer-brewing. Again, the presence or absence of suspended matter is of importance with reference to the need for filtration. Loch Katrine supply to Glasgow does not require filtration because of its freedom from matters in suspension. A river-supply, however, must needs be filtered because of the presence of suspended matters, and more especially because of the possible presence of the specific micro-organisms of disease.

Biological or Bacteriological Examination of Water.—The purity of any water may be also estimated from the number and kind of micro-organisms it contains per cubic centimetre. It may be held as expressive of a general truth that the larger the number of micro-organisms present in that unit quantity of water, the more plentiful the amount of organic matter therein, and the greater the potentialities of risk to the consumer. But mere number of organisms per c.c. of water is by no means a safe, guiding index of risk in consumption, since the organic matter may be of vegetable and not of animal origin. Where, however, pollution by animal matter is likely, or indeed is possible, such a water would *a priori* be suspicious, because of the possibility of its containing specific organisms of disease, such as *B. typhosus*, *B. choleræ*, *B. enteritidis sporogenes*, *Amœba coli*, *B. coli communis*, and others. It is quite true that there is great difficulty in isolating these organisms, and chiefly the first two named, from a suspected water-supply, and less difficulty with the others; but so soon as *B. coli communis*, *B. enteritidis sporogenes*, or either of them is found in a potable water, its use becomes a positive danger, as sewage pollution is certainly betokened. Chemically pure waters contain but few organisms, but waters rich in organic matter contain them in abundance. Standards of purity of water may be based upon that and like facts. Miguel has proposed that waters should be divided into two classes—viz. pure and impure. Those waters ought to be deemed pure which contain less than 1000 microbes per c.c., those impure which contain over 1000 and under 100,000, and those to be very impure, more than 100,000 per c.c.

To collect samples for bacteriological examination, small glass bulbs rendered vacuous, and drawn out to a fine extremity which is sealed, are convenient for use. Their sterilisation is effected by heat. The bulb is partially filled with water when the top of its capillary extremity is broken under water. When the operation is completed, the capillary point is sealed at a flame. If any time is to intervene between the sample-taking and the examination, each bulb should be placed separately in a tin with cotton-wool, and the tins surrounded by ice. Petri-plate cultures in gelatine and agar-agar should then be made with 0·1, 0·2, 0·5, and 1 c.c. respectively of the water, and after incubation at 22° C. and 37° C. for the gelatine and agar-agar respectively. The colonies which grow on these plates should be counted where the numbers can be counted, and the mean of the numbers found, calculated into 1 c.c., will represent the number of organisms, divided into moulds and micro-organisms, in 1 c.c. of the water-sample. Thereafter, pure cultures must be made of these colonies which are suspicious, so that by their cultural and morphological characteristics they may be identified. On these points, however, reference must be made to bacteriological works.

Hot-Water Supply of a House

In most houses of any pretensions which are supplied with water from a gravitation supply, a hot-water system for the supply of hot water for culinary purposes, baths, wash-hand basins, etc., is commonly introduced. The source of heating the supply is a boiler which is placed behind the fire of the kitchen-range, is commonly of a saddle or horse-shoe shape, and is constructed of iron or copper. In such an installation, a cistern must be placed at the top of the house, the position usually chosen being one between the ceiling of the topmost room and the roof of the house, so that from the contents of the cistern cold water may fill the place of the hot water drawn off at any point of the supply. By the house-branch pipe from the street water-main water is conveyed to this cistern, which is the highest point of the circulation. The supply from the cistern is solely intended for the hot-water system and to feed the boiler. The water from it may be used for cooking provided that all risks of contamination and pollution are prevented. This may be accomplished by constructing the cistern of slate, covering it with an iron, slate, or wooden hinged lid, and ventilating it by means of openings for the outlet and inlet of air, as shown in Fig. 50. In most houses, unfortunately, too little attention is paid to this cistern, with the result that it very often becomes a receptacle of miscellaneous material, of which dirt from the roof, the decomposing bodies of drowned mice and rats, and plaster are common examples. Owing to such pollution risks to health are engendered. Unless, therefore, every care against contamination has been taken in the construction of the cistern, it is wiser that the water, unless for ordinary culinary operations, should not be used. By means of a system of pipes which forms a complete circulatory apparatus, hot water is conveyed to the different parts of the house where it is needed, and the pipes are kept constantly full from the cistern in the roof. Reference to Fig. 50 and to the explanation given will provide the reader with an intelligent conception of the principles of hot-water circulation.

The course of the circulation—assuming for the moment that the circulation is being established for the first time—is as follows: From the cold-water house-supply-pipe water rises to the roof-cistern, which it fills to a certain level. This level is regulated by a ball-valve which, rising with the water-level, gradually cuts off the water-supply as the fixed level is reached, and finally stops the supply when that level is attained. The cistern is provided with an over-flow pipe, which is only operative, however, should, from any reason, the ball-valve fail to act. This over-flow pipe is passed through the roof to the outside of the building at a point usually a little above the level of the eaves. From the cistern passes the cold-water supply-pipe to the boiler in the kitchen-range, into which it enters near its bottom. From the boiler proceed two pipes—one from the top of the boiler carrying upwards the heated water to the hot-water reservoir, or hot-water cistern as it is commonly called, and another from the lower part of the boiler but at a higher level than the cold supply-pipe, which acts as a return pipe from the hot-water reservoir. This reservoir is usually placed in the kitchen near the roof at some convenient point, or in the bathroom where that apartment is located in the flat above and over the kitchen—as is not uncommon in small villa houses—in which case it warms the bathroom. From the top of the reservoir passes the main hot-water supply-pipe, from which branch pipes pass to the necessary fittings in the house. This pipe is continued up through the different flats, and terminates in a curved ending outside the roof, thus acting as an expansion-pipe. Since the water in this pipe will rise nearly to the height of its source, *i.e.* to the bottom level of the roof-cistern, the sanitary fittings in the top flat may be supplied with hot water. In order to maintain the principle of a circulatory system, a pipe is connected with this hot-water pipe near that level, by which the water may pass back to the hot-water reservoir. This pipe in plumbing language is called the *hot-return-pipe.* In this way, therefore, the circulation of hot water is maintained so long

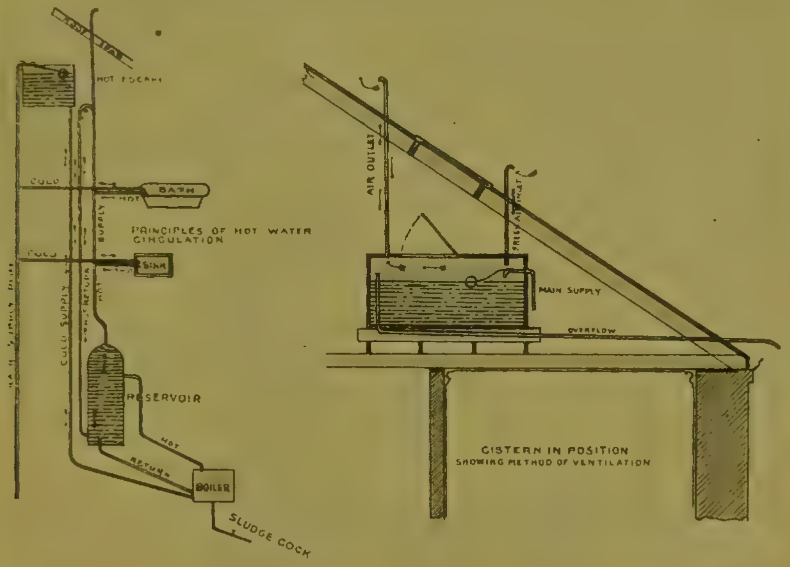

FIG. 50.—The Figure on the left of the Diagram illustrates the principles and mechanism of Hot-Water Supply to a House. The Main Supply-Pipe conveys water to the cistern—the highest point of the circulation—and from this pipe branches are connected to Baths, Sinks, Wash-Hand Basins, etc. From the cistern proceeds the cold-water supply-pipe to the hot-water boiler behind the kitchen-fire, which it enters close to its bottom. From the top of the boiler passes the hot-water pipe to the reservoir or hot-water storage-cistern from which proceeds the hot-water supply-pipe, by branches from which various fittings are supplied with hot water. The hot water not required passes back by means of the hot-water return-pipe, in a partially cooled state, to the lower level of the hot-water storage cistern to aid in the supply to the hot-water boiler. The course of the circulation of water is indicated by the arrows. The figure on the right shows a model method of ventilating and keeping clean the contents of the cold-water cistern. The top of the cistern is covered, and a hinged lid permits of sufficient space for inspection and repairs. It is ventilated by openings in pipes which open below in the cistern in the air-space above the water-level, and, above, into the open air above the roof.

as the roof-cistern contains water. But there are certain risks attaching to hot-water installations. These are dependent entirely on a failure of supply of cold water to the boiler. Should for any reason—as freezing of the contents of the house branch pipe or the cistern, or failure of supply owing to necessary repairs in the street-mains—this happen, and should the hot water in the pipes be drawn as usual for the needs of the household, the pipes are gradually emptied and there is a likelihood that steam will be generated in the reservoir or boiler owing to "short circuiting" of the circulation. In the system shown in Fig. 50 this is unlikely to happen, because long before risk of explosion has become imminent —if such a risk could happen at all—attention would be drawn to the unusual condition by the lack of hot water in the pipes of the upper rooms, and thus forewarned, time is afforded so that the services of a skilled workman can be obtained. Disastrous explosions, accompanied even by loss of life, have, however, not infrequently occurred where certain forms of hot-water installation other than that shown in the figure have existed. Various measures have been proposed to prevent such occurrences. Owing to the great household discomfort which follows the withdrawal of the kitchen-fire for even comparatively short periods of time, the following measures have been proposed to allow the kitchen-fire being used—viz. the temporary extinction of the fire and then to block the passage below the boiler against the flames with a poor heat-conductor as fine ashes, or to put a false back to the fire in the form of a sheet of iron and to fill an interspace between it and the front of the boiler with the same non-conducting material. Some, however, have proposed, as a safe preventive under any circumstances, to put an escape or safety-valve in the upper part of the boiler itself, which would permit the escape of steam at its first formation, relieve internal pressure in the boiler, and so prevent the possibility of the occurrence of an explosion.

CHAPTER VII

HOUSE DRAINAGE

The waste matters which are formed in houses must be disposed of by suitable arrangements, and in populous centres, in addition, the refuse accumulations of the streets, and those arising from the keeping of animals. These waste products are comprehended under the following heads—viz.

(*a*) Liquid Refuse, including night-soil and waste-water;

(*b*) Ashes, food-waste, and other débris.

The former, in a water-carriage system, is called sewage, by which is meant everything which passes along the drains or sewers irrespective of its origin or character. It includes waste-water, excreta, rain-water, and trade discharges. The removal of solid débris of whatever kind, but chiefly that of households, is technically known as *scavenging*. In most large populous places, a water-carriage system of removal of sewage and a scavenging system are both required.

In the economy of Nature, it was intended that the excreta of man should be returned to the soil to form the food of plants, but owing to the gregation of Man this intention has been disturbed. During the Middle Ages, and up till the first half of the last century, excrementitious products were accumulated in receptacles situated near occupied houses, and because of these epidemics broke out and death and depreciated health resulted. Even to-day the conditions respecting the removal and disposal of excreta and house-refuse vary. In villages and small towns where there is no public water-supply—a condition which is, fortunately, now rare—excreta are deposited in a privy connected with an ash-pit, and after accumulation are removed for agricultural use. In such circumstances, where houses are few and are distributed over a comparatively wide area, and where the domestic water-supply is not obtained from wells in the neighbourhood of such deposits, probably little or no harm ensues; and this is particularly true where earth-closets are in use, because of the deodorant and disinfectant properties of the earth used. In other small towns, or in individual houses, with a gravitation water-supply, and where there is no general concerted drainage system, although the sewage of the house is carried away by pipes, it is simply discharged into a cesspool sunk in the ground, over an adjacent plot of land, or into a neighbouring rivulet. But in modern towns and cities, such conditions have perforce disappeared. It may happen that in certain towns which have passed through different phases of sewage and refuse disposal, small areas are to be found in which the privy or ash-pit system still prevails; but these are becoming fewer. In populous places, therefore, a well-conceived plan of sewage-convection and disposal must be in operation for the removal of human excreta, the liquid refuse of stables and cow-byres, refuse fluids from slaughter-houses and manufacturing processes, the waste-water of houses, and the rainfall.

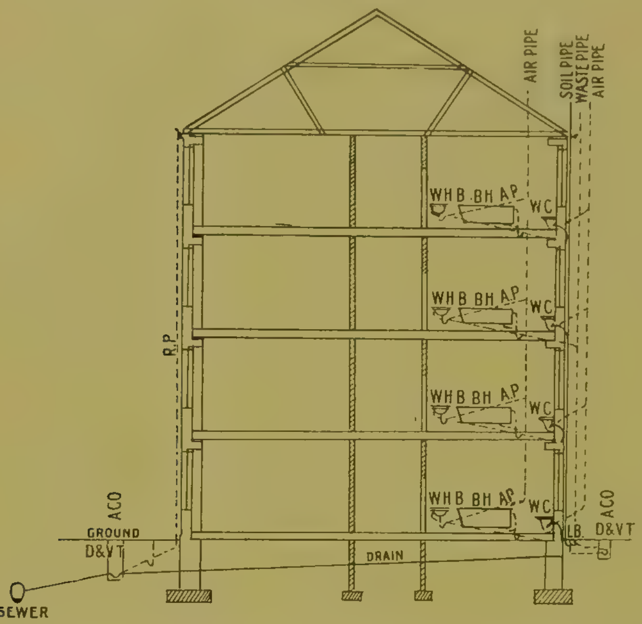

FIG. 51.—Arrangements of Draining a Tenement Property. WH.B. = Wash-Hand Basin; BH. = Bath; A.P. = Air-Pipe; W.C. = Water-Closet; D. & V.T. = Disconnecting and Ventilating Trap; Ac.O. = Access-Opening; R.P. = Roof-Pipe.

Leaving aside for the moment the disposal of solid refuse, attention may first of all be directed to the arrangements necessary in a dwelling which is connected with a water-carriage system of sewage.

The sanitary fittings necessary in a dwelling of the poorest class are the following, viz.: (*a*) a kitchen-sink and waste-water pipes; (*b*) a water-closet. In better-class houses, in addition to these are (*c*) wash-hand basins, (*d*) baths, and (*e*) urinals. These fittings may be differentiated in respect to whether they contain or not excrementitious products. The bath, wash-hand basins, kitchen-sinks, and rain-pipes belong to the waste-water system, the water-closet and urinal to the other. All the fittings of the former system are connected with the waste-water pipe, those of the latter with the soil-pipe. The rain-water pipes or conductors may, however, be separate. The contents of waste-pipe, soil-pipe, and rain-conductors alike are ultimately discharged into the house-drain by which they are passed on to the sewer. Since the contents of the house-drain, and more particularly those of the sewer are in a state of active decomposition, and since foul-smelling and other gases are given off therefrom, it becomes necessary to interrupt the continuity of the channels by the intervention of traps. The object of sanitary fittings, therefore, is not only to ensure the expeditious removal of liquid and solid excreta and

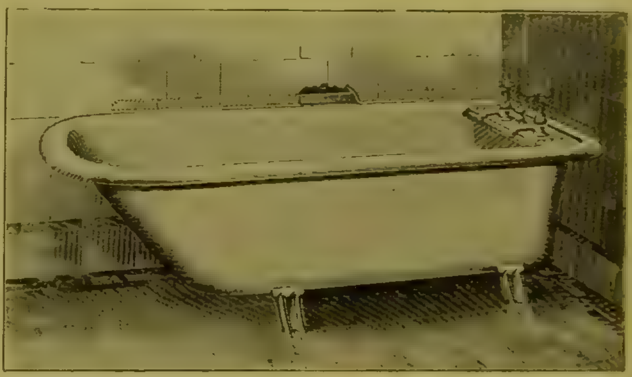

FIG. 52 shows a Modern Bath placed in a position in a Bathroom in accordance with modern requirements, viz.:—Standing clear of walls and floor, and without surrounding wood-work.

waste-water from the house, but also the prevention of the possible return of gases of decomposition, etc., to the air of the dwelling.

The various above-named fittings must now be considered with reference to their fitness for the duty they have to perform. These will be dealt with under the heads of (A) Waste-water System, and (B) Soil-pipe System.

Waste-Water System

(A) Belonging to the former are (1) Baths, (2) Wash-hand basins, (3) Kitchen- and Pantry-sinks.

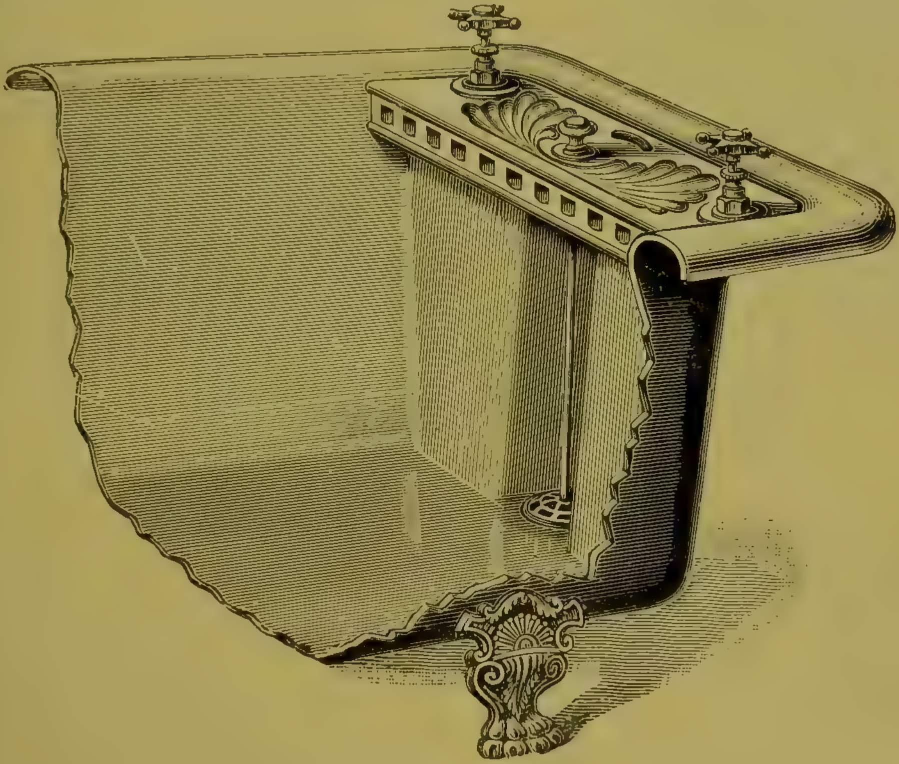

FIG. 53.—Bath fitted with single exit-channel for waste-water and overflow.

Baths.—In the bulk of houses, the bath is placed in the same apartment as the water-closet and wash-hand basin, owing to exigency of space. There is no reason of a sanitary kind which can be urged against the practice, although there are of inexpediency. In many older houses in towns, particularly those in flats, the bath-room is too frequently an imperfectly lighted, ill-ventilated, and small room; in more modern dwellings, it is as it ought to be, well lighted and capable of being well ventilated. The bath itself should stand clear of the floor, so that the space below and around it may be easily cleaned, and its sides should be placed away from a wall for the same reason; and it should possess an amply supply of hot and cold water, the former preferably from the general house-supply. It is usually constructed of cast-iron. From it the waste-water and overflow are carried away by a branch-pipe to the waste-pipe, on which branch-pipe a trap is placed. For houses which possess no general hot-water supply, instantaneous heaters have been devised for baths, whereby, by a series of Bunsen burners which heat a convoluted pipe through which cold water passes, the water is heated.

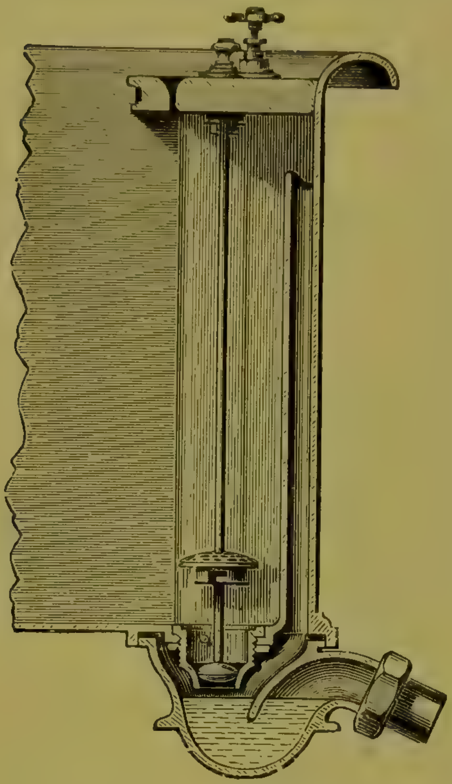

Fig. 54.—Section of Bath, showing arrangements for waste-water and overflow, with trap. When the water in filling the bath rises higher than the lower margin of the dark shading to the right of the Figure, it flows over directly into the trap by the channel seen on section at right margin of Figure.

Care must be exercised in the use of these owing to the generation of carbon monoxide gas, which has already caused fatal accidents. In most modern baths, the waste and overflow channels are combined by different makers, as is seen in the figure below. (Fig. 55.)

Wash-hand Basins.—These fittings are but miniature baths adapted in shape and in position for the purpose intended. The fittings of a basin ought to be exposed, like those of the bath, for the purposes of cleanliness and the better detection of leaks. The "tip-top" basin, which being mounted on a swivel may be quickly emptied, is a useful contrivance, inasmuch as the sudden rush of outflowing water assists to keep the pipes clean. The "aseptic" basin of Shanks & Co., intended for hospital use, is an ingenious arrangement for hand-sterilisation.

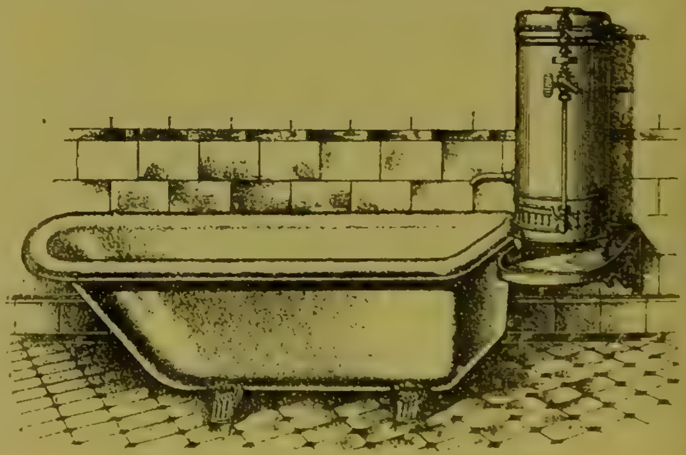

Fig. 55.—Bathroom fitted with Water-heater.

The Maxtone-Thom Water-Tap or Mixer.—This tap, which is the invention of Dr Maxtone-Thom of the Royal Infirmary, Glasgow, presents some novel features. (Fig. 56.) Originally devised for the use of surgeons, it will prove of excellent service for baths and wash-basins. The bulbous portion contains the mixer into which passes the cold-water and hot-water supplies. The hot and cold water valves inside the mixer face each other, while a disc, which is fixed on the handle and which has inclined planes, is situated between these valves. The lower valve admits the cold water and the upper, the hot water. When the handle is first turned, the inclined plane on the lower part of the disc impinges on the cold-water valve and gradually raises it. When it is running full, the inclined plane on the upper surface of the disc impinges on the hot-water valve and gradually raises it. At the same time the cold-water valve is gradually closed; and if the handle be turned further, it is completely closed. When the cold-water valve is closed, the hot-water valve is running full. In turning the handle in the opposite direction the process is simply reversed. The handle being removable, once the proper temperature of water is running and the handle removed, the top cannot be tampered with, and thus scalding accidents are prevented.

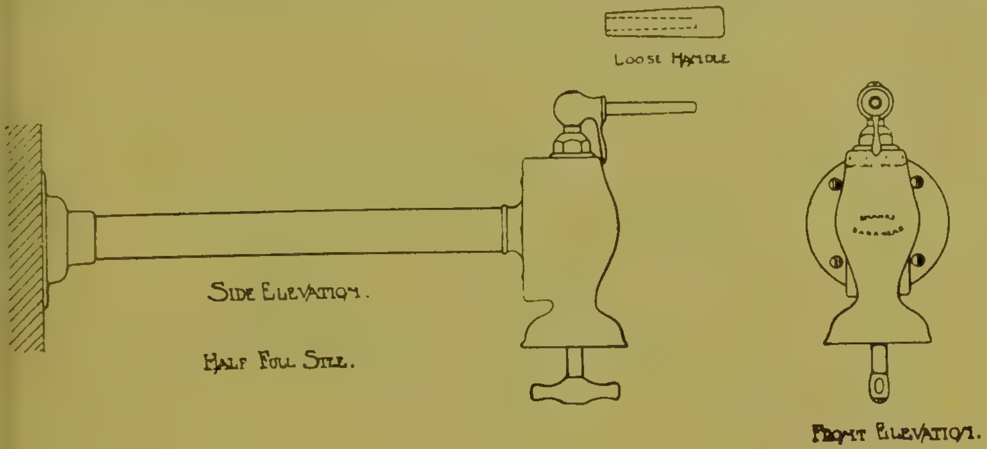

Fig. 56.

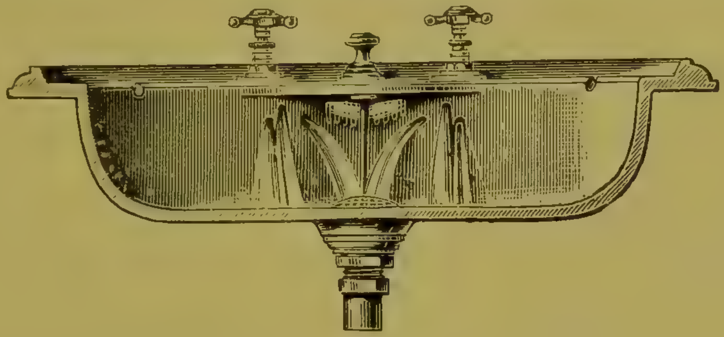

Fig. 57.—Elevation of "Aseptic" Wash-Basin.

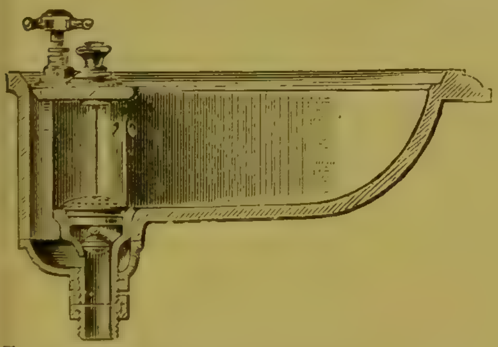

Fig. 58.—Section (longitudinal) of "Aseptic" Wash-Basin, with waste-water and over-flow exit-channel provided as in Baths.

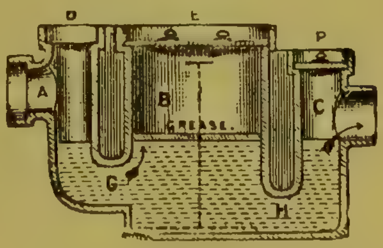

Fig. 59.—Buchan's Grease-Trap.

Kitchen- and Pantry-Sinks.—These are best made of enamelled iron or earthenware, ought to be sufficiently capacious and of oblong shape, and the grated and perforated waste-pipe grated opening ought not to have too large openings, to prevent solid detritus being swept through and thus blocking the]traps. Its fittings should stand open.

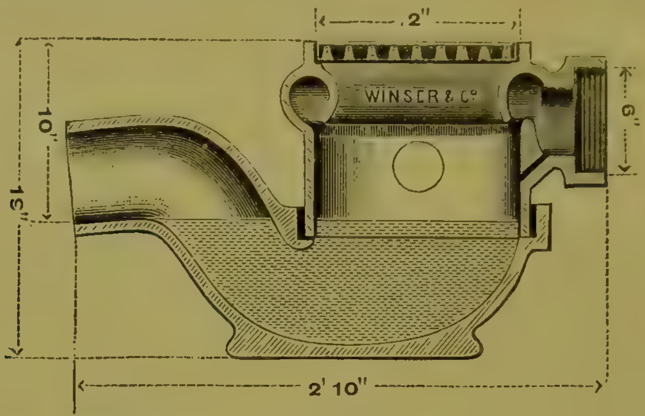

Fig. 60.—The Winser Grease-Trap with a flushing-rim, in connection with a small flushing-tank.

It should not be surrounded by woodwork, because such hides an accumulation of dust and decomposing soapy and other materials. Since from such sinks greasy fluids are passed into the waste-pipe and drains,

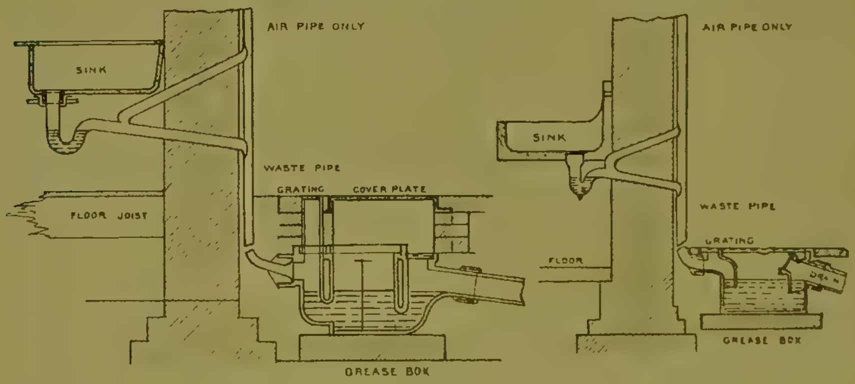

Fig. 61 is intended to illustrate the connections between the kitchen-sink, waste-pipe, and grease-trap. It is to be noted that the grease-traps are placed in the Figures higher than they should be with relation to the flooring, solely for convenience of diagram-space. This is indicated by the severance in continuity of the waste-pipe before it enters the grease-box or trap.

and since these are liable on cooling to coat the pipes and trap, and thus produce blocking, special arrangements must be made for preventing this. The device usually adopted is a special form of trap of which Buchan's is probably one of the best. Fig. 59 is an illustration of it.

The inlet is marked by *A*, and the arrows indicate the direction of flow of fluids; *B* is the grease-chamber in which fatty matters solidify, and from which they may be removed periodically by the movable cover *E*; *C* is the outlet, by which grease-free water passes into the house-drain; *D* and *P* are openings by which the trap may further be cleansed. The congelation of the fatty matter is assisted by making the inlet of the trap higher than the outlet, and the tongue of the trap nearest the outlet lower than that nearest the inlet. The trap is placed in an accessible position for cleansing, and serves efficiently its object.

The contents of these fittings are discharged into the *Main Waste-Water Pipe.* This pipe may be made to pass downwards from the highest fitting either on the inside of the house-wall or on the outside. Provided that at its lowest part it passes to the exterior of the house, and that it is disconnected from the house-drain either by opening over a trapped gully or into a ventilating trap, no strong objection can be offered to its being placed on the inside. Indeed, there are advantages associated with this latter location: its joints are less subjected to alternate expansion and contraction from heat and cold, and are, therefore, less liable to be loosened, the pipe itself is less liable to become warped, and its contents less likely to be frozen in winter. It is an open question whether a waste-pipe should be made to discharge its contents in the open over a grated gully at the ground-level, or should be made to do so into a ventilating trap below that level. The determining factor ought to be the exposure of the pipe in respect of the points of the compass. If the exposure is on the south or west, the open method is probably the better; if on the north and east, the underground method. The reason for this is the liability of the mouth of the grated gully to become frozen over, if blocked by partial obstruction, and succeeding discharges of waste-water from the house-

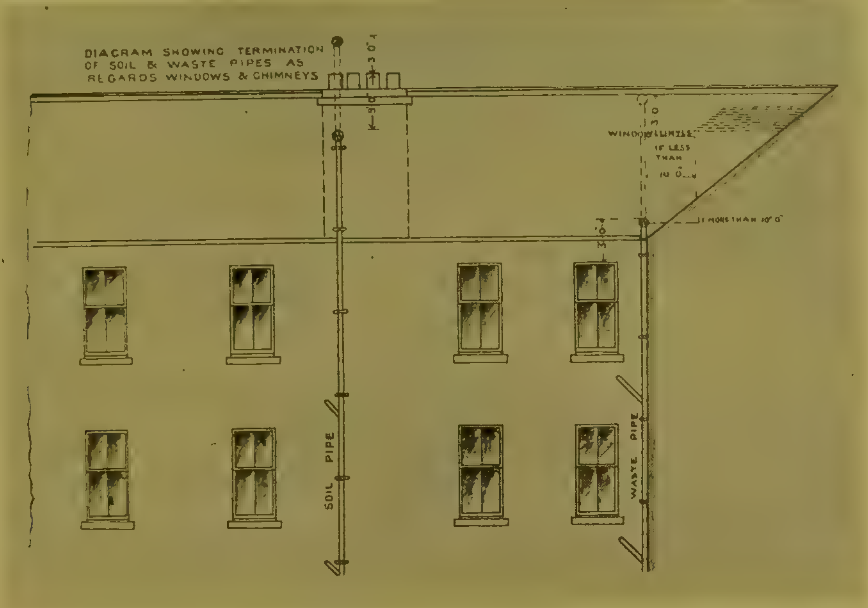

FIG. 62.—To illustrate the relations of ventilation of soil-pipe and waste-pipe to windows and chimneys of dwellings. In Building Regulations of various towns and cities, the upper end of soil-pipes must not be less than 8 feet clear of windows. No soil-pipe terminus should be within 3 feet over or under a chimney-top. Waste-pipe termini should not be less than 5 feet from a window or chimney, or less than 3 feet if the window or chimney be within a radius of 20 feet.

fittings to be diverted over the surface of courtyard or pavement instead of passing into the house-drain.

Rain-Water Conductors.—These pipes belong to the waste-water system. In many cases they are formed by an extension upwards to the eaves of the waste-pipe, where they are connected to the eaves-channels. But in large buildings, they are also found as separate pipes. If they are joined to the house-drain as they usually are, they must be trapped, especially where at the eaves they are in close proximity to attic or other windows. Their contents are commonly discharged into court-yard gullies, which are made of special form to arrest any solid matter which may be carried into them by the rainfall. This solid residue is periodically removed.

From the foregoing, therefore, the following principles may be enunciated: firstly, that all fittings which discharge waste-water should be connected with a waste-pipe only; secondly, there ought to be no communication between waste-water fittings and the soil-pipe system.

It has been urged, however, by some sanitary engineers that there is no need whatever for two parallel pipes from a bath-room, one for carrying away waste fluids and the other night-soil, provided that the plumbing workmanship is thorough, and that it has been subjected to a sufficient test to establish its efficiency. Such argue that both pipes are more or less foul, they both carry fluids of different degrees of pollution, and both have the same destiny; why, therefore, since each fitting which is connected with the separate waste- and soil-pipes at present is separately trapped by a ventilated trap, need there be more than one main pipe which should combine the duties of waste and soil-pipe? Much can be said in favour of this view; first, it reduces the number of channels connecting the house-fitting with the house-drain; second, the soil-products would be better flushed into the house-drain; and, generally, removal of all products would be simplified. These are legitimate arguments when the integrity of these channels can be assured by periodic testing, as ought to be done, but so long as such channels, their branch connections, and their traps are liable to imperfect construction, and are not tested at periodic intervals, the connection of waste-water fittings to a soil-pipe would multiply the chances of sewer-air and foul gases gaining an entrance into houses. Until, therefore, such periodic testing of sanitary fittings becomes a more prevalent practice, it is safer to have separate channels or pipes to carry away waste-water and excretal products respectively, and to disconnect the former pipe from the house-drain before its entrance thereto.

Soil-Pipe System

(B) *Soil-Pipe System.*—The fittings in the dwelling which belong to this system are the following: (1) Water-Closet and Slop-Closet; (2) Urinal; (3) Main Soil-Pipe.

Water-Closet.—The apartment in which this fitting is placed ought to be capable of free ventilation. For tenements, where the apartment is used by many persons, the system of "cross" ventilation, which may be secured by providing windows in the walls of the apartment at right angles to the doorway, is the best. Every apartment of this kind should, compatible with personal comfort, be abundantly flushed with air. In most "flatted" houses of four or more rooms of the older type, this apartment is supposed to be ventilated by a window which opens upon the landing of the common stairway. As a matter of fact, however, by reason of the higher temperature of the house interior, the direction of the current of air is from the window in question through the closet apartment into the dwelling itself. In more modern dwellings, the position of this apartment has been improved, but the mode of ventilation, in the above respect, is not different.

In the Model Bye-laws issued by the Scottish Association for the National Registration of Plumbers, it is suggested that no water-closet should be placed in an apartment which has not an external wall for one of its sides, and which does not contain a window in such wall of at least 6 superficial feet of glass, and which has not one half of the window made to open ; such apartments in top-flats, however, may be lighted and ventilated from the roof. The object of this is to provide better facilities for placing the soil-pipe on the wall outside of the dwelling. In Section 251 of the Burgh Police (Scot.) Act, 1892, the above provisions are enacted. In Section 53 of the Glasgow Buildings Regulations Act, 1900, the minimum window-space is fixed at 6 superficial feet, the window being constructed to open to the extent of at least one half. The Regulations of Aberdeen and Greenock contain like provisions to the above model bye-law in respect of the position of the water-closet apartment, but the lighting and ventilation must be sufficient, although the particulars of the window-dimensions are not specified.

During the last twenty-five years the water-closet has undergone a variety of changes, and that toward perfection. Although its use was not unknown in the days of Pompeii, and, in isolated instances, in this country in the sixteenth century—as, for example, " A Priuie in Perfection," the plans and working parts of which are described by Sir John Harington in a work entitled " A New Discourse of a Stale subject called the Metamorphosis of Ajax," 1596 [1]—the first water-closet was patented—a valve closet—in 1775 by Alexander Cummings. Bramah, the famous mechanician, also invented a valve closet which is still called by his name. Since then, many patterns have been invented and many patents taken.

The closets in use at the present time belong to one of four different classes—viz.

(*a*) The valve closet ;
(*b*) The pan closet ;
(*c*) The hopper closet ;
(*d*) The " flush " closet.

The Valve Closet.—The chief merit of this form is that the contents are suddenly projected into the trap on release of the valve, and the chief objection, that the valve is liable to be unfitted from the valve-seat by any substance which becomes lodged at the valve-seat, thereby allowing leakage of the water which should remain in the fitting. Except in the case of one or two specially good forms, the valve-closet has largely gone out of use. (Fig. 63.)

The Pan Closet.—This form is still largely used, but is not now being put into new houses, the more modern forms taking its place. Its installation into new buildings or old buildings remodelled is prohibited by the Model Bye-laws of the English Local Government Board. Bye-law 65 of the Glasgow Buildings Regulations Act forbids that any container or other similar fitting should be placed beneath the closet-basin; each closet must be provided with a suitable trap, but no D-trap or lead mid-feather trap shall be regarded as suitable. It is composed of the following parts, viz.: (1) an earthenware basin; (2) a copper pan which forms the bottom of the basin, and by which a certain amount of water is retained in the basin; (3) the receiver, trunk, or container composed of rough cast iron, into which (1) and (2) are fitted; and (4) the trap. The handle of the closet which is pulled upwards, operates at the same time to open the cistern for flush water and to depress

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[1] *B.M.J.*, vol. ii. 1900, p. 1861 *et seq.*

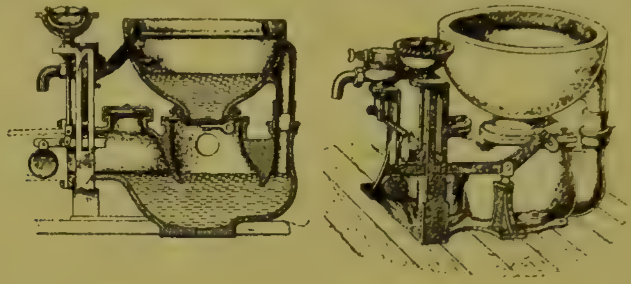

FIG. 63.—Valve Closet, Section and Elevation.

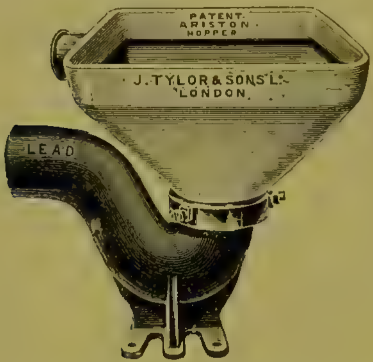

FIG. 64.—Tylor's Wash-down Closet. The basin is purposely widened to enable the apparatus to be used also as a slop-closet.

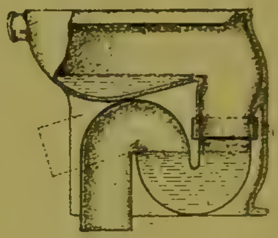

FIG. 65.—Section of a Wash-out Closet.

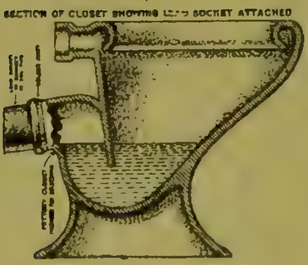

FIG. 66.—Section of a Wash-down Closet.

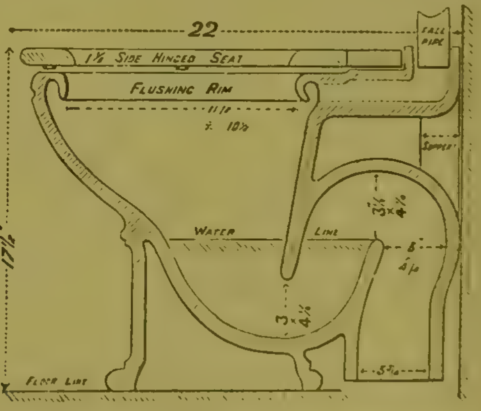

FIG. 67.—Section of Wash-down Closet showing the Closet fitted in position.

the pan, thus emptying and flushing the pan at one pull. The obvious objections to it are, first, that it is composed of too many parts ; second, that the very parts which require cleansing are most difficult of access, and third, that the trunk or receiver becomes coated with excreta, and because of its greater width and area than the pan, cannot be flushed with water. Whether the trap attached to it be a D-trap or an S-trap, it is a most objectionable form of fitting, and it ought to be removed from houses.

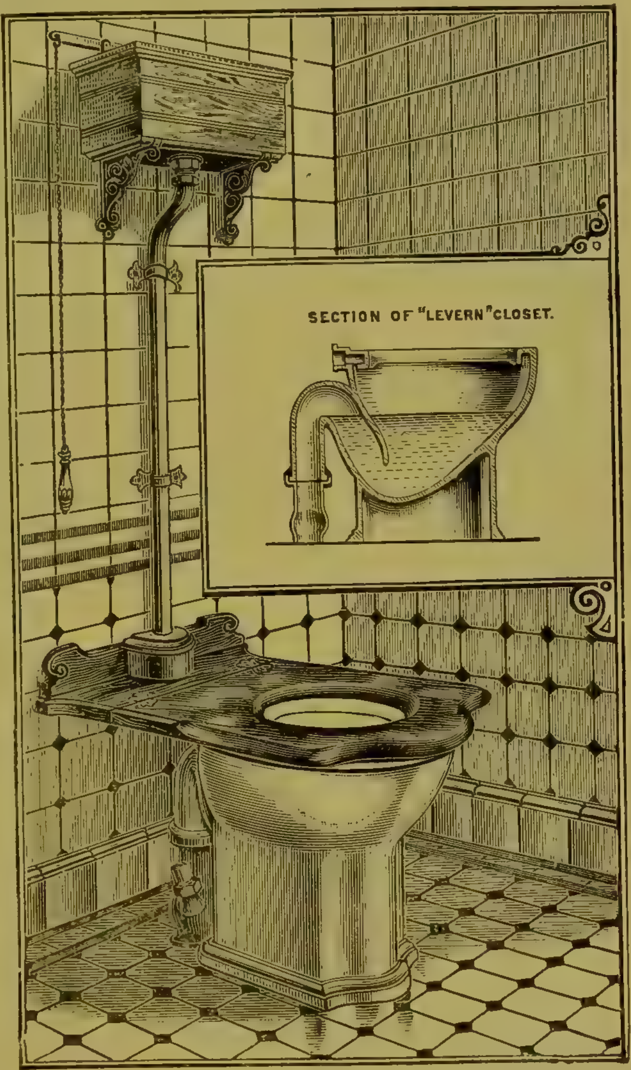

Fig. 68.—Elevation of the "Levern" Siphonic Closet, and section of basin and connection with branch-pipe.

The Hopper Closet.—These, especially the long conical hopper, have fallen into desuetude ; the long hopper particularly, since it is impossible to clean it with any flush of water. Less objection can be offered to the short hopper, provided the water-flush be sufficient.

Flush Closets.—These are best when composed of one piece of earthenware, since trap and closet being combined there are no joints liable to become loosened. Such apparatus, when fitted with a movable hinged seat, may serve the purposes of a urinal and slop-closet. They have no mechanism to get out of order, they can be fitted in position without any surrounding wood-work, and they can be easily cleaned.

They are divisible into two main forms, depending upon the mode of action of the water-flush upon their contents, and they are called *Wash-out* and *Wash-down* closets respectively. In the wash-out closet the excreta are deposited upon a projecting ledge within the basin, and because of the action of the water-flush in washing out such deposit into and through the trap, it receives the above name. In the other class the action of the flush is to *wash down* the excreta through the trap, since primarily, in this form, the excreta are deposited straight into the water of the trap. It is, therefore, apparent that with an insufficient water-flush there is more likelihood of imperfect action in the wash-out than in the wash-down closet, and since part of the force of the flush is spent in overcoming the extra resistance of the ledge, and in sweeping the contents into the trap, the excreta may be left in the water of the trap, instead of having been swept through it and into the soil-pipe. Where however the water-flush is sufficient, there is little to choose between them in respect of efficiency. Of this same type of closet, but with special arrangements for emptying, is the "Siphonic" Closet, which is so called because the contents of the basin are emptied by siphonic action. In its most modern form it is a good closet. The action of the siphon is started by the direct action of the water from the flush-pipe. In the "Levern" closet, the lower part of the long leg of the siphon is of patented construction and is made of lead.

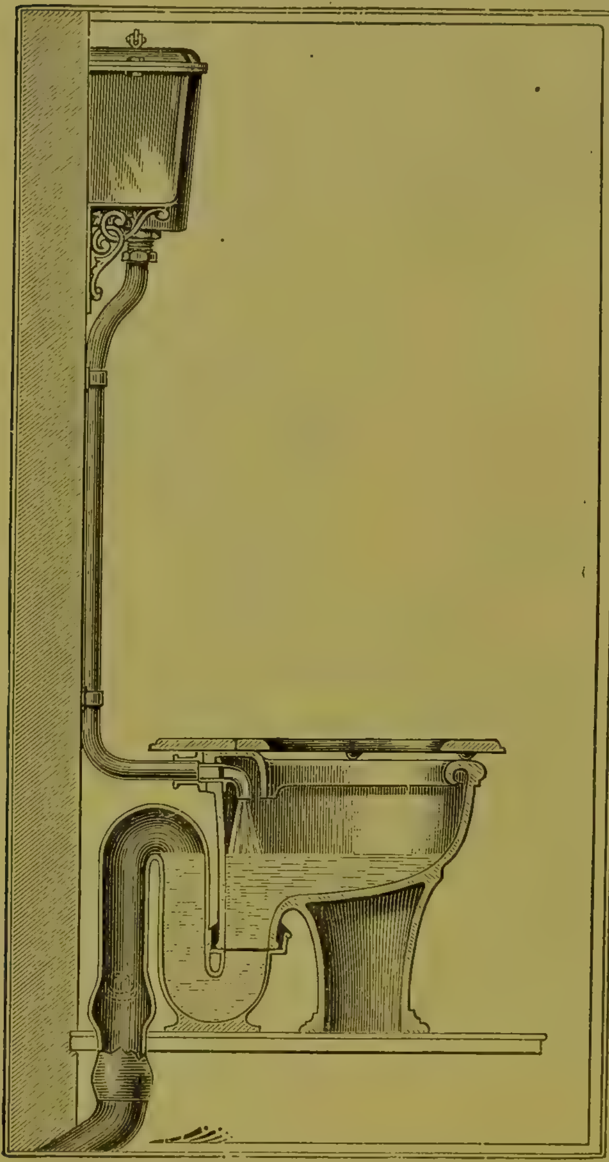
FIG. 69.—Section of "Levern" Siphonic Closet, showing siphon arrangements.

A necessary part of such a closet is an efficient cistern, which is commonly sold by the makers as part of the fitting in order to ensure effective action. The objection to these closets which operate by siphon action, is that the siphon action may be initiated by throwing in slop or other waste water, and thus the trap may be left unsealed. This, however, has been overcome in one of two ways, viz.: (*a*) either by introducing an anti-siphonage pipe which prevents the action of the siphon except by the flush set agoing in the ordinary way; or (*b*) by fitting it with Dicksee's patent arrangement, whereby, if the siphon action is set up by the addition of extraneous water, cistern action is simultaneously set up, and thus the trap is kept full of water. While, therefore, between wash-out and wash-down closets with good flush there may be little to choose, preference on the whole ought to be given to the wash-down form, since more effective flushing of trap and contents results. But such apparatus must be periodically cleansed, else the inside of the trap, so far as it can be seen, becomes coated with deposit; and the best material for the purpose is a strong solution of washing-soda applied by means of a closet-brush.

The characteristics which a good closet ought to possess are the following, viz.: (1) It should be of such a form as to enable easy and perfect dislodgment of contents by the water-flush; (2) It should possess a sufficient trap; (3) All its parts should be accessible for cleansing; (4) The water-flush should be ample.

For schools and public conveniences trough closets are used. In these the basins open into a continuous water-receptacle which extends the whole length of the number of closets. They are either periodically flushed by an attendant, or by an automatically-acting flush cistern, when the contents of the water-receptacle are swept through the trap at the outlet end into the drain.

In certain towns, as Birmingham, closets are fitted for rows of houses upon the same principle, and the flush is obtained by the waste-water of the houses, which is passed into a tank at the end of the row furthest from the sewer. On the automatic action of the cistern when full the contents are swept into the sewer.

Provision of Sanitary Conveniences for Workshops and Factories under the Factory and Workshop Act, 1901.

In pursuance of the terms of section 9 of the Factory and Workshop Act, 1901, the Home Secretary issued an order which deals with the provisions of sanitary conveniences in places coming within that Act, called—

The Sanitary Accommodation Order of 4th February, 1903, in which it is determined that the accommodation in the way of sanitary conveniences provided in a factory or workshop shall be deemed to be sufficient and suitable within the meaning of section 9 of the Act if the following conditions are complied with, and not otherwise:—

1. In factories or workshops where females are employed or in attendance, there shall be one sanitary convenience for every 25 females.
2. In factories or workshops where males are employed or in attendance there shall be one sanitary convenience for every 25 males; provided that—

(*a*) In factories, etc., where the number of males employed or in attendance exceeds 100, and sufficient urinal accommodation is also provided, it shall be sufficient if there is one sanitary convenience for every 25 males up to the first hundred, and one for every forty thereafter.

(*b*) In factories, etc., where the number of males employed, etc., exceeds 500, and the district inspector of factories certifies in writing that by means of the check system, or otherwise, proper supervision and control in regard to the use of the conveniences are exercised by persons specially appointed for that purpose, it shall be sufficient if one sanitary convenience is provided for every 60 males, in addition to sufficient urinal accommodation. Any certificate given by an inspector shall be kept attached to the general register, and shall be liable at any time to be revoked by notice in writing from the inspector.

In calculating the number of conveniences required by the Order, any odd number of persons less than 25, 40, or 60, as the case may be, shall be reckoned as 25, 40, or 60.

Every sanitary convenience shall be kept in a cleanly state, shall be sufficiently ventilated and lighted, and shall not communicate with any workroom except through the open air, or through an intervening ventilated space :—

Provided that in workrooms in use prior to 1st January, 1903, and mechanically ventilated in such manner that air cannot be drawn into the workroom through the sanitary convenience, an intervening ventilated space shall not be required.

3. Every sanitary convenience shall be under cover and so partitioned off as to secure privacy, and if for the use of females shall have a proper door and fastenings.
4. The sanitary conveniences in a factory or workshop shall be so arranged and maintained as to be conveniently accessible to all persons employed therein at all times during their employment.
5. Where persons of both sexes are employed, the conveniences for each sex shall be so placed or so screened that the interior shall not be visible, even when the door of any convenience is open, from any place where persons of the other sex have to work or pass ; and, if the conveniences for one sex adjoin those for the other sex, the approaches shall be separate.
6. This order shall come into force on 1st July, 1903, and may be referred to as the Sanitary Accommodation Order of 4th February 1903.

The Water-Flush.—The amount of water to be used as flush at each time of using a closet ought not to be less than two gallons, and, when possible, should amount to three gallons. It should reach the basin of the closet by a pipe of not less than 1½ inches in diameter. The cistern which supplies the flush should hold the quantity needed, should be set in action by the user of the closet, should be beyond his control from the time of initiation till the completion of the act of flushing, and should supply no other fitting than the closet. Any other arrangements than these are objectionable. If, for example, the flush supply is obtained from the cistern for the house hot-water supply, and if there be no arrangement for the regulated use of the needed quantity, either too much or too little water is used. To overcome this proverbial carelessness, arrangements in the mechanism of the closet have been made whereby the flushing is set in operation by closet-seat action. Fig. 71 illustrates this.

But of all the arrangements in existence probably the best is that which secures, that when the operation of flushing is started it goes on to a finish without the attention or control of the initiator. In public conveniences, the siphon cistern which acts periodically and automatically is used. The cistern is usually situated against the wall several feet above the closet to give the water-flush sufficient velocity, but the action of such a cistern is usually accompanied by much noise.

To overcome this, and where the arrangement of the apartment will not permit the introduction of a high-placed cistern, a combination of closet and cistern has been made. Fig. 74 is an illustration of the elevation plan of the fitting. It is claimed for this cistern that it is noiseless in action, discharges the full flush suddenly, and that the mere movement of a lever, seen on the left side of the cistern, secures the discharge of the whole contents of the cistern into the closet-basin.

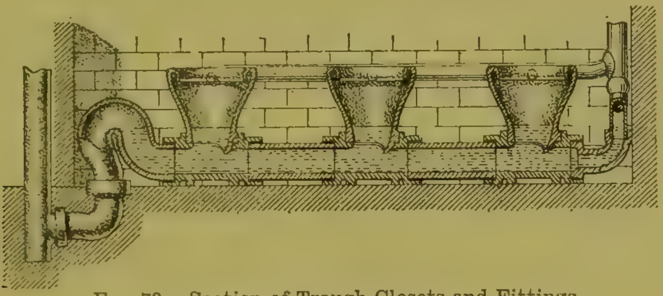

FIG. 70.—Section of Trough Closets and Fittings.

It has already been observed that a water-closet provided with a hinged seat may be utilised as a slop-closet; but it has one drawback where many slop-vessels have to be emptied, and that is, there is not provision for washing clean the utensils after emptying. The arrangement shown in Fig. 75 is a fitting by Doulton for this purpose. Such apparatus is of great service in a large private house, in hotels, and in hospitals. Another contrivance for use in isolation hospitals which can be fitted to the slop-closet, is a grid with perforated openings, which, when turned down over the slop-basin and the utensil placed over it mouth-downwards, throws upward streams of water into the vessel, and thus thoroughly cleanses it without the application of the hand, or other instrument.

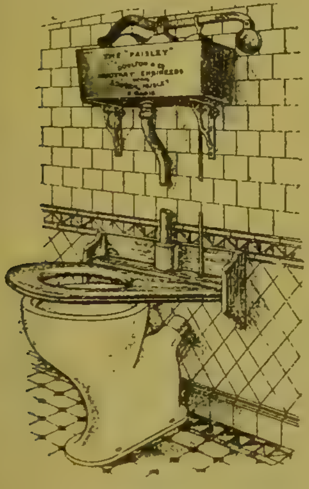

FIG. 71.—Elevation of Closet, in which flush is automatically started by the user.

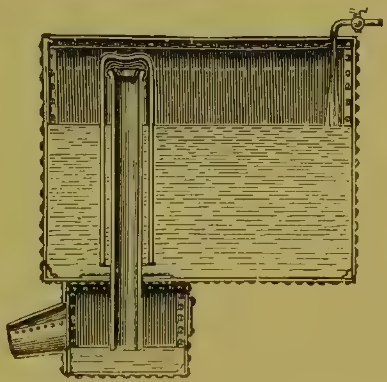

FIG. 72.—Field's Automatic Flush-Tank.

The Closet Cistern ought to combine the following requirements, viz.: (1) To supply at each time of action three gallons of water; (2) To fill rapidly after being emptied; (3) To project the water suddenly

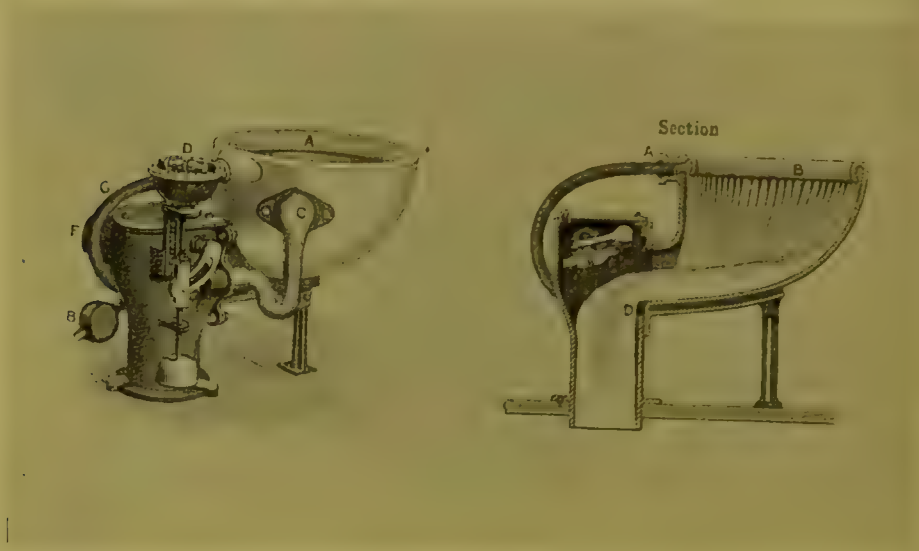

Fig. 73.—Trapless Water-Closet. This is a fitting which ought not now to be used.

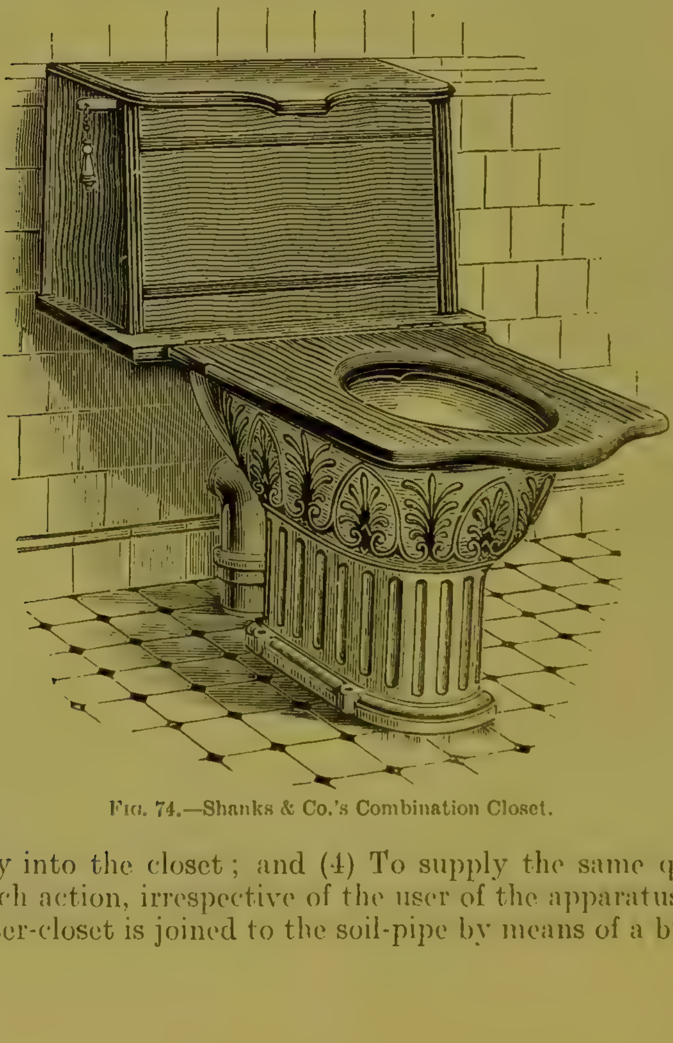

Fig. 74.—Shanks & Co.'s Combination Closet.

and forcibly into the closet; and (4) To supply the same quantity of water at each action, irrespective of the user of the apparatus.

The water-closet is joined to the soil-pipe by means of a branch-pipe which is composed usually of lead. The closet itself being earthenware and the branch-pipe lead, attention must be given to the mode of joining the two together, since by imperfect junction sewer-air and sewer-gases would obtain entrance into the apartment. Too commonly, the materials used are red lead cement and cloth. Owing to the different ratios of expansion by heat of lead and earthenware, this very soon becomes insufficient. This difficulty has, however, been overcome by the new metallo-keramic joint, which is composed of a combination of white metals, and forms not only at first a perfect connection but also, from observations we have made, a durable connection.

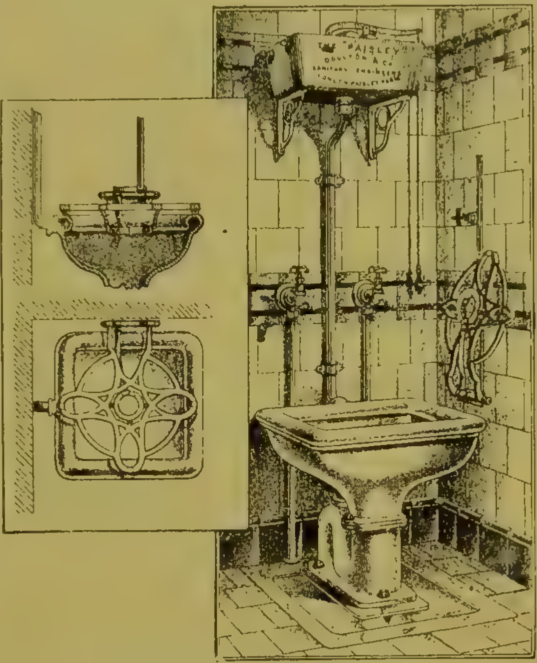

FIG. 75.—Slop-Closet fitted with grid for washing slop-utensils. It saves the use of the hands.

The Soil-Pipe.—The pipe which is solely employed for the convection of excreta from a house is called the *soil-pipe*. It is composed of lead or iron, most usually of the latter. When of the former, its joints are rounded or flanged; when of the latter, the joints are "filled" with lead. No soil-pipe should be less than 3½ inches internal diameter. If of lead, it should weigh not less than 7 lbs. per square foot, if of iron, 54 lbs. per 6-foot length. The joints between the lead pipe and vitrified material, in the case of lead, should be made by means of a brass ferrule which has an end flange of like diameter to the faucet of drain-pipe. The lead pipe passes through the ferrule and is soldered thereto by means of a wiped or burnt joint. This produces a better and more rigid joint than any other method. In the case of iron, the joints are made with rope yarn and molten lead.

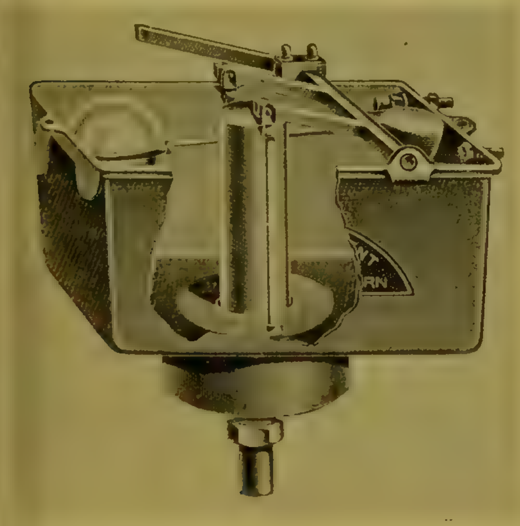

FIG. 76 represents an excellent type of Cistern—the "Reliable" Waste-Preventer.

Since the soil-pipe is employed for the above purpose, it should be placed on the outside of the house-wall. Each closet, slop-closet, and urinal-fitting in the house is connected to it by means of a branch-connection which is trapped between the point of connection and the fitting, usually near the fitting itself. Fig. 62 represents the position of the soil-pipe on the house-wall. The soil-pipe should extend from a point three to five feet above the eaves to below the level of the ground where it is joined to the house-drain. Its diameter should be the same throughout its whole length, and curves and angles should be avoided lest accretions of filth form in its interior at such points, and also in order that ventilation through it is not reduced.

The diameter of the pipe must depend upon the work it has to do, and therefore must be relative in size to the number of fittings which empty into it. For an ordinary house of two or three flats a 4-inch pipe will be ample; but for larger buildings, such as hotels, barracks, etc., a 6-inch pipe may be required. The topmost opening should not be near attic windows: if its course should run in such a direction, the top of it ought to be carried for at least three feet above the window.

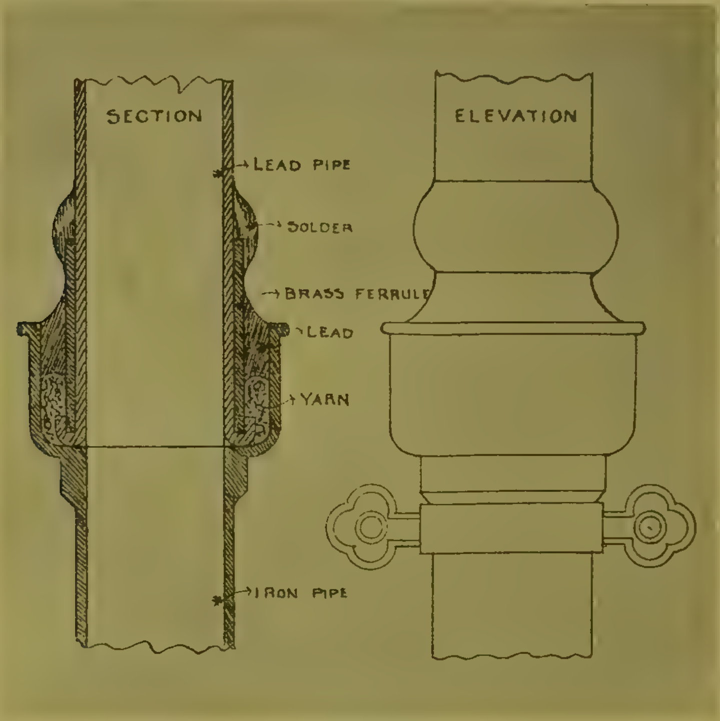

FIG. 77.—To illustrate mode of uniting a lead with an iron pipe by means of a brass ferrule.

At some point between the junction of the soil-pipe with the house-drain and the sewer a disconnecting-trap is commonly placed, in order that by the ventilating opening of the trap air may enter and pass through the whole shaft. It has been a common practice, indeed, to place the disconnecting-trap at the point of junction of soil-pipe and house-drain. Objections have been offered, however, to placing a trap in this position, particularly at the point of junction of pipe and house-drain, since resistance is offered, it is urged, to the free egress of sewage from the house sewer-wards. But if ventilation of the soil-pipe is to be secured, it must be effected either in this way or by erecting a separate ventilating shaft to allow of the liberation of pressure of air which may take place in the sewer. If the ventilation of the sewer itself be ample, however, it is contended that there is no likelihood of pressure forming therein sufficient to force the traps of the fittings, which are joined to the soil-pipe. There is, at the same time, another objection to placing the disconnecting trap near windows, or on the pavement in streets, and that is because of the foul air which is driven out of the ventilating eye of the trap on descent of a column of discharging fluid. It is better to place the trap where it is least likely for the above reason to prove objectionable, and that position must be determined by individual circumstances. Periodic inspection of all the fittings of a house connected with the soil-pipe ought to be made, since for a variety of reasons joints are apt to become shaky, and to permit of the entrance of the soil-pipe air into that of the apartments. The lead which composes the branch-connections and that of the filling of joints is liable to be attacked by the gases dissolved in the fluids or by the fluids themselves which pass through them. This is especially true since disinfectants have come into popular use. The corrosion which is thus initiated tends to end in perforation. Another source of mischief is perforation of the pipes by rats in their eager quest for water. In Glasgow, several years ago, a mysterious outbreak of disease broke out in St Mary's Reformatory, giving rise to anomalous symptoms and which was believed by Dr Russell, Medical Officer of Health, to have its origin in drain-emanations due to this cause.

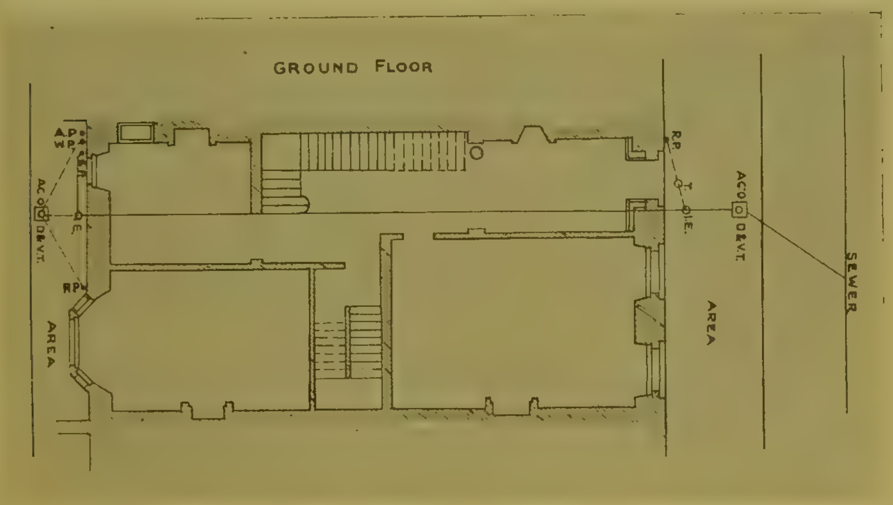

FIG. 78 illustrates a Model Ground-Plan of Draining a House in a Terrace. A.P.=Air-Pipe; W.P.=Waste-Pipe; S.P.=Soil-Pipe: I.E.=Inspection Eye or opening; R.P.=Roof-Pipe for carrying Rain-Water; Ac.O.=Access-Opening; D. & V.T.=Disconnecting and Ventilating Trap; T.=Trap. From the figure it will be seen that the soil-pipe and waste-pipe pass down on the outside wall of the back of the house to the Disconnecting and Ventilating Trap in the back area, that the combined waste-water, roof-water, and soil pass by the house-drain underneath the main passage in the basement of the house to another trap in the front area, and thence to the sewer in the street.

We have seen several examples of corrosion and perforation from the above causes. The piece of lead soil-pipe shown in Fig. 79 is in possession of the author. It was taken from a tenement building, from which enteric fever or diphtheria was hardly ever absent.

The House-Drain.—The house-drain is that part of the drainage-arrangements of a dwelling which is situated between the point of entrance of soil-pipe and waste-pipe and the common sewer in the roadway. Since the object to be attained is the carriage of the sewage and liquid waste products of the dwelling into the sewer by the effect of gravity, careful attention to its course and its levels is necessary. The course or alignment of a drain ought to be as straight as possible, and if curves upon it must be made, such must be open curves, in order to offer the minimum obstruction to the flow. It must be also placed on a gradient from the entrance of the soil-pipe—its highest point—to the centre of the street sewer—its lowest point. By proper alignment and gradient, therefore, expeditious removal of products is effected; where, on the other hand, bends exist in the course of the drain, resistance is offered to the flow, and the same effect is produced by insufficient gradient, hence "silt" is apt to form, and sooner or later, by the accumulation of silt or sediment, the drain acts imperfectly or becomes choked. Should the gradient be too great, the momentum of the passing discharges is apt to siphon the trap as the discharges pass through. The fall or gradient, therefore, must have relation to the size of channel in order to obtain the requisite velocity of flow of liquid contents. The usual rule is: for a 4-inch pipe, a fall of 1 in 40; for a 6-inch pipe, 1 in 60; for a 9-inch pipe, 1 in 90. In the Model Bye-laws already referred to, the fall recommended for a 4-inch pipe is 1 in 36. This gradient has been adopted by Aberdeen. In Edinburgh, it is enacted that where practicable it shall be not less than 1 in 40, and in Greenock, not less than 1 in 48. In order to obtain these gradients, the level can only be properly adjusted by some such instrument as

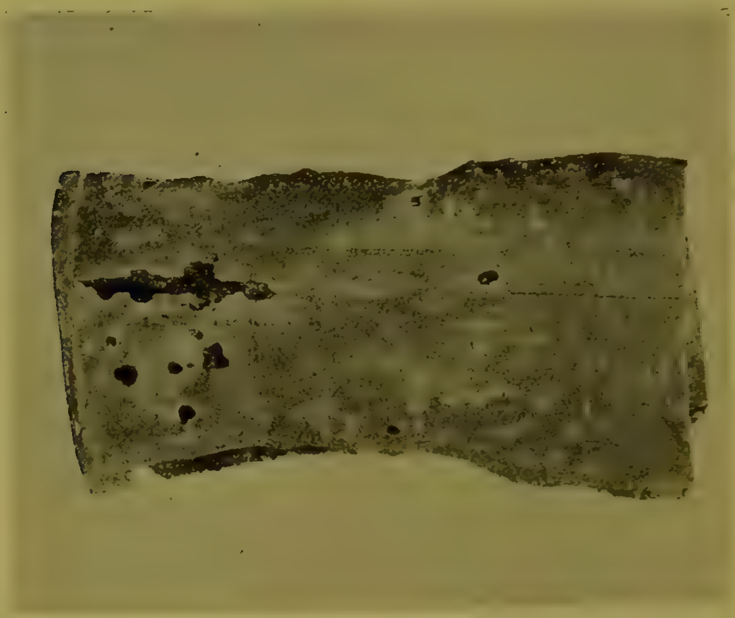

FIG. 79.—Portion of Lead Soil-Pipe eaten into and perforated by the action of sewer-gases. (In possession of Author.) In the house from which the above was taken, diphtheria and enteric fever had attacked the inmates more than once.

Moss-Flowers' gradient indicator, as shown in the accompanying igure.

The house-drain is commonly composed of fireclay pipes with spigot and faucet joints, but of late years it has been proposed to substitute iron pipes in their place. In the case where the house-drain, by reason of architectural necessity or otherwise, is required to pass through or under a building, it should be composed of heavy cast-iron spigot and faucet pipes, the walls of which are not less than $\frac{3}{8}$-inch in thickness.

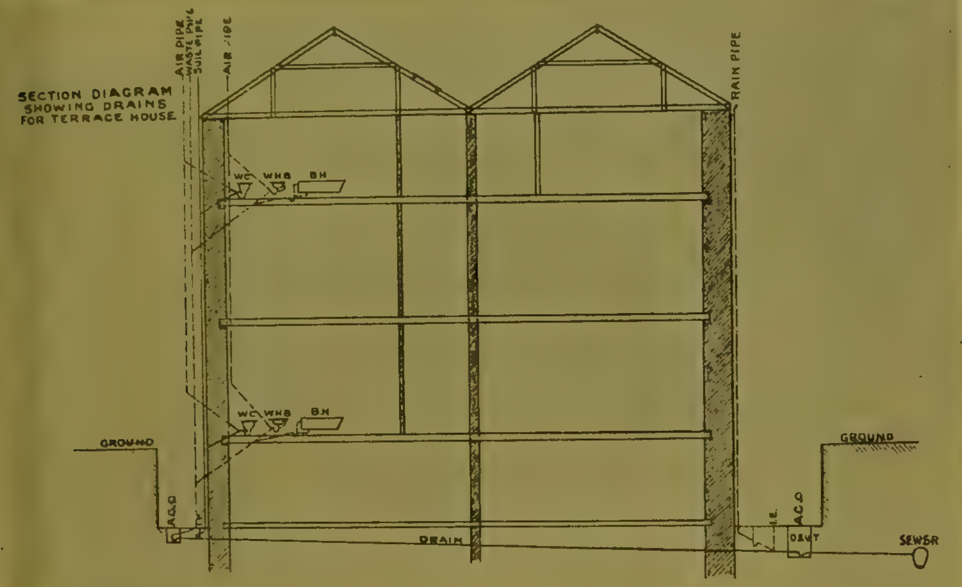

Fig. 80 is a Section Elevation-Plan of a Terrace House, showing the arrangements of waste-pipe, soil-pipe, roof-pipe, traps, and house-drain. W.C. = Water-Closet; W.H.B. = Wash-Hand Basin; B.H. = Bath. The other terms as in previous Figure.

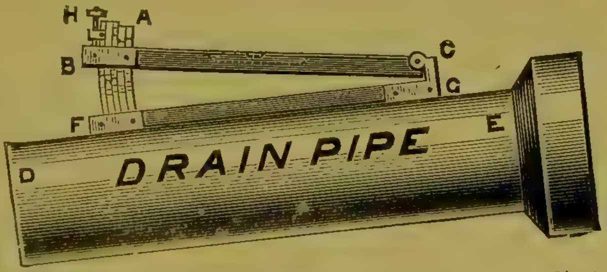

Fig. 81.—Gradient Indicator. A = brass scale to indicate gradient; B, C = spirit-level; D, E = drain-pipe to be laid; F, G = drain limb of instrument which is applied to line of pipe; H = tangent screw to secure exact adjustment.

The joints of a fireclay drain should be made with rope yarn steeped in cement rammed well home and Portland cement, each joint cleaned inside of "feathering," and left smooth; those of an iron-pipe drain should be made with rope yarn and molten lead. Where cement is used in jointing the section-lengths of fireclay piping, the work should be left for 48 hours to enable the cement to set thoroughly. Iron pipes used for this purpose ought to be coated externally and internally with Angus Smith's solution applied hot, in order to prevent corrosion, and if they are to be laid in earth their walls ought to be $\frac{1}{2}$-inch in thickness. In order to give stability and equality of resistance to pressure to the house-drain, it is necessary that it should be laid upon an even, solid foundation. If this be not done, some of the joints or pipe-lengths are liable to be broken on "settling" of foundations of house. The best foundation for a fireclay drain is a bed of fine concrete or cement, care being taken that the faucet ends of the pipes are embedded in the material. To ensure this, the lengths of fireclay pipes have been made with pedestal feet as shown in Fig. 82. The feet are embedded in the concrete or cement bed, and thus give fixity and stability to the entire drain. This is especially important where the drain passes through or under a building. In such cases, it is indeed better to envelop the pipe, except at the inspection openings, in asphalt, and a free overhead space of not less than 3 inches should be allowed at the walls or partitions for subsidence. And the same is true where buildings have been erected upon "made" or "filled" sites, owing to the greater liability of uneven settling of foundations. All junctions with a house-drain, whether horizontal or vertical, should be made obliquely and in the direction of the flow. Right-angled connections are quite impermissible, because of the obstruction to the flow thereby produced. Where drains from a large building converge, the junction should be effected obliquely by means of a bend (*vide* Fig. 85).

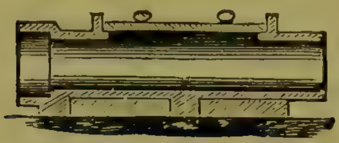

FIG. 82.—Fireclay Drain-Pipe Section made with pedestal addition, and with inspection opening on upper surface.

While it is a cardinal principle of house-sanitation that house-drains should not pass through or under buildings, it must be clear that this cannot always be achieved in towns and cities with continuous lines of street of houses, and where the sewers are situated in the roadway. In order to avoid unsightliness of rows of pipes on the house-elevations, the fittings of houses requiring waste- and soil-pipes are usually put in apartments at the rear of the houses. These, therefore, must enter the house-drains, which must be brought through or under the houses to enter the street-sewers. In tenement flatted houses, the house-drain is caused to pass under the common entry, and in terraced, single-occupant houses through the passage in the basement flat of the house. If the constant integrity of the house-drain after efficient initial installation could be assured, it matters little whether the drain be carried from rear to front through, under, or outside of the house; but in view of the absence of periodic inspection and the possible imperfection of the drain, special precautions must at first be taken to secure that it is air-tight. In such cases, the top of a drain should be not less than six inches below the level of the lowest floor beneath which it is put.

House-drains, apart from initial faults of alignment or gradient, may fail in their purpose from several causes, viz.: (*a*) rupture of pipes due to uneven settling of buildings; (*b*) want of connection with the street-sewer; (*c*) blocking of channel from accident or carelessness. By the Burgh Police Act, 1892, section 180, it is enacted that the entire drainage-arrangements of a house must be inspected and tested to satisfy the Local Authority of their sufficiency. The Glasgow Building Regulation Act, 1900, section 57, prohibits the occupation of any new building, or of any building altered for the purpose of increasing the

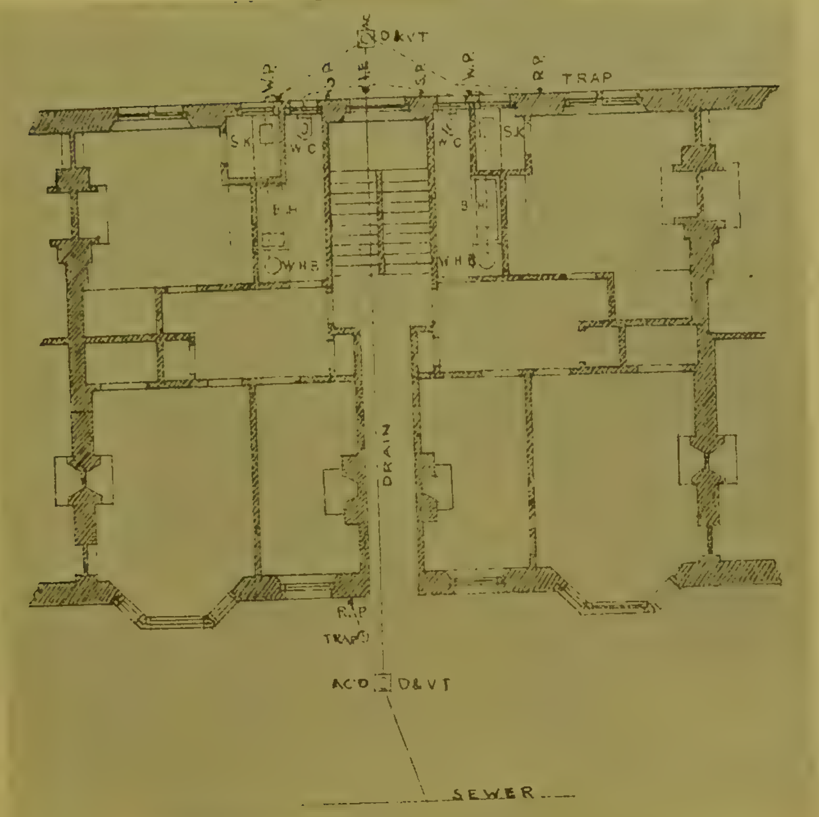

Fig. 83.—Plan of Draining a Tenement Property. The soil-pipes and waste-pipes pass down the back wall, and their contents into the house-drain, which, in order to reach the sewer in the street, is taken through the common entry. W.P. = Waste-Pipe ; S.P. = Soil-Pipe ; D. & V. T. = Disconnecting and Ventilating Trap ; R.P. = Rain-Pipe ; Ac.O. = Access-Opening.

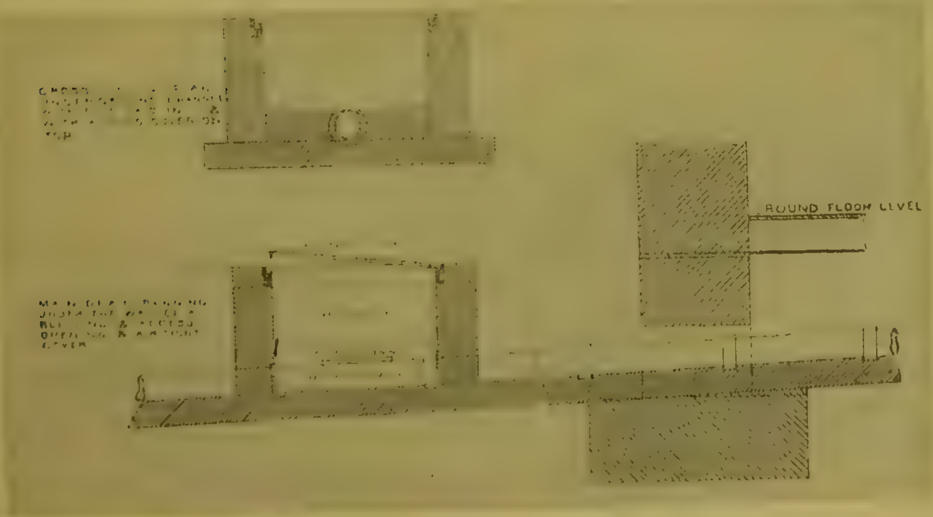

Fig. 84.—To illustrate mode of laying a house-drain which runs under the wall of a building. The upper figure shows the cross section ; the lower, the section elevation.

number of occupiers, until these arrangements have been inspected and tested by the Sanitary Inspector and found satisfactory, and until a certificate to that effect has been deposited with the Master of Works. In the case of new buildings, however, it does not appear to us that this test is sufficient of itself, since owing to the settling of the foundations during the early months of occupancy, some part of the drainage arrangements may have become broken, loosened, or even detached. Such would be indicated, probably, by cracks occurring in the walls of the house; in which case it would be absolutely necessary to re-test the integrity of the arrangements. But defects may take place in the drainage-system without such marked signs as the foregoing, and, therefore, it would be better to renew the tests after some months of occupancy, the period to be determined by the character of the ground upon which the houses are built. In view of such inspection, it would seem impossible that a house-drain from a tenement building could be left unconnected with the sewer. But we have seen such a case, where the defect was only discovered after the building had been occupied for a time sufficiently long to fill up the drain and internal fittings of the ground-flat houses with the accumulated sewage of the building. The liability to this is no doubt due in part to the dual control which exists in Scotland in the construction of the drainage-arrangements of dwellings. While it is the function of the plumber to deal with the installation of water, gas, and sanitary fittings, with their necessary pipes and connections inside and outside of the house, the mason steps in and declares that the plumber's duty ends at the ground, and that it is the function of the mason to lay the house-drain and make the necessary connection with the sewer. So long as the house-drain continues to be constructed of fireclay with cement joints, so long will this controversy continue. It would cease at once, however, if it became the common practice to use iron pipes instead of fireclay pipes. There is much to be said in favour of placing the entire responsibility of workmanship upon one contractor, and of the use of iron instead of fireclay for house-drains.

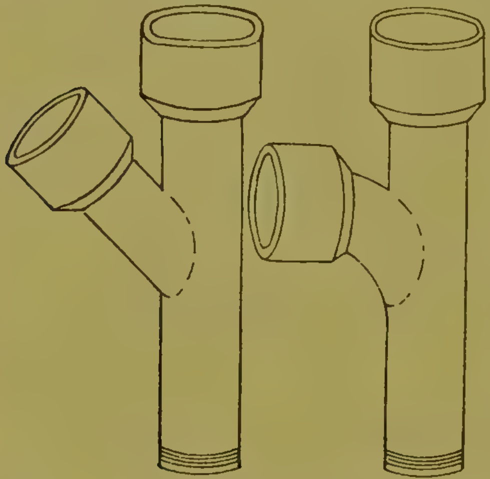

FIG. 85.—To show method of connecting Branch-Pipes with Main Drain-Pipe.

Blocking of a house-drain not infrequently arises in tenement houses from carelessness or negligence of householders. Experience has shown that the obstructing causes may be scrubbing-brushes, washing-cloths, dusters, and sometimes materials much more foreign than these to house use. To overcome such obstructions, provision in the house-drain must be made in the form of access or inspection openings. These are provided with securely fixed, air-tight, covers, and are placed not only at junctions and changes of direction, but also at distances of from 20 to 40 feet apart in the straight course of a house-drain. Fig. 86 illustrates such in position. Such openings must be built to the ground-surface of sufficient size to enable the introduction of flexible iron rods for the removal of obstructions. Special care must be taken respecting the tightness of these openings in drains which pass through or under buildings.

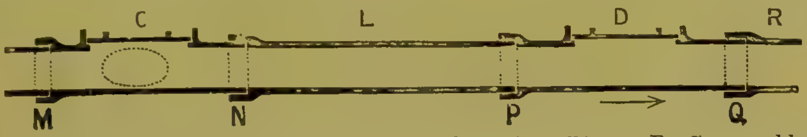

Fig. 86.—Section of House-Drain composed of Iron Pipes. D, C, movable inspection covers, by which interior of drain may be inspected or freed from obstructions; C is placed at a junction. L is an ordinary pipe-length. M, N, P, Q indicate joints. The arrow points in the direction of the sewage-flow.

For large buildings where a number of discharge-pipes converge at a particular point, it is better to construct an inspection-chamber in the floor of which the main channel runs in an open form, and with which the branch-connections unite. This chamber may be, indeed ought to be, situated as far from windows and doors as possible, should be ventilated by a shaft extending above the roof of the house or houses, or by one placed alongside of an out-house, and should be disconnected from the sewer by a suitable trap.

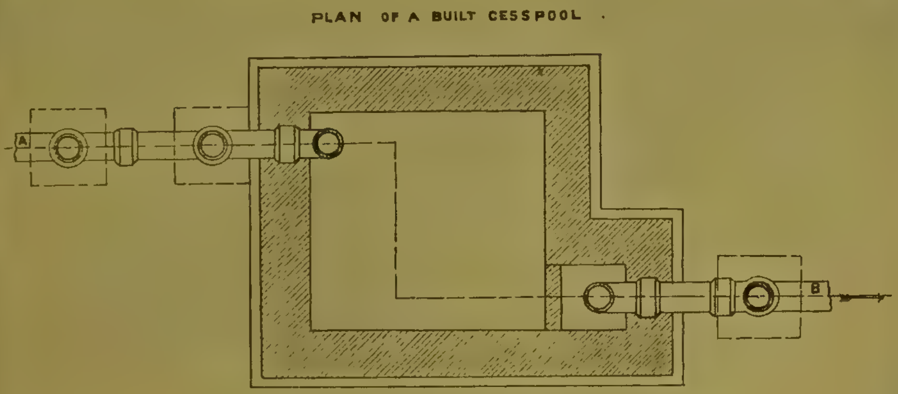

Fig. 87 is a Plan of a Built Cesspool or Inspection Chamber. The cesspool is constructed of concrete. By the fireclay pipe-channel A the sewage enters, and by the like-channel B it leaves to be disposed of or purified. The top of cesspool is covered by a solid iron plate which can be removed for the purpose of cleaning the cesspool. (Model Regulations of Plumbers.)

The requirements of an efficient house-drain are these, viz.: (1) it should be aligned in as straight a course as possible, or with open curves; (2) it should be provided with access or inspection openings at suitable points and at suitable distances; (3) it should be laid on an even, solid bed of concrete or cement; (4) it should have a sufficient gradient; (5) all branch-connections should be made obliquely and in the direction of the flow; (6) its interior should be smooth;

(7) it should be disconnected from the soil-pipe by an efficient intercepting or disconnecting ventilating trap, which should not open on a pavement or close to windows or doorways.

TRAPS

Frequent mention has been made in the foregoing chapters of traps, and from what has been said it will be rightly concluded that traps are essential parts of a system of house-drainage. When by means of circular channels the sewage and waste-water of houses came to be removed from houses to sewer, and even, indeed, before that period when square brick-built drains were in use, by reason of the discovery that foul-smelling gases passed backward through the uninterrupted continuity of pipes, it was found necessary to devise some arrangement to prevent this occurrence. This was achieved to some extent in the square brick-built drain by the dipstone trap, an arrangement whereby a flat stone placed at right angles to the flow of sewage dipped into the water of a cesspool constructed in the course of the drain, and so acted as a preventive of the passage backward of foul air from sewer to house. But when the circular or pipe form of drain was adopted. the trap had to take a new shape. Hence the most elementary forms consisted of a simple bend in the pipe, or of a depressed tongue. The above figure (Fig. 88) illustrates the "dipstone" principle adapted to the circular pipe, which was devised by Mr John Honeyman, LL.D., Architect, of Glasgow in 1858. The only drain-trap which was at that time in use was very defective, and it was impossible to use it in connection with the ventilation of drains. To the newly-devised form of trap Honeyman gave the name "Somerset" but he never patented the trap. Buchan, however, a few years later, after some modifications in form, did patent it.[1]

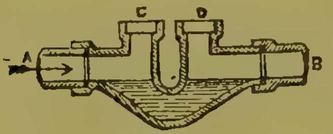

Fig. 88.—Honeyman's "Somerset" Trap. A=drain from house. B=drain to common sewer or outfall. C=opening for cleaning trap. D=opening for ventilation, which may be continued to a ventilation-pipe on wall of house, or merely brought to surface level of ground.

Object of Traps.—The original purpose of a trap was to arrest the passage backward of the foul-smelling gases of decomposition from the house-drain or the sewer into the air of the apartment in which fittings connected with the drain by pipes were placed. Experience has shown that not only may such gases, in the absence of traps or with imperfect traps, so enter, but that foul and putrescible particulate bodies and micro-organisms may equally pass. The medium used for the arrest of such substances is water more or less impure, and the point of arrest or trap is situated between the house interior and the nearest adjacent fouled pipe or channel The column of water which lies in the bend of the trap of a circular pipe (Fig. 89) is called the *water-seal* or *water-lock;* in other forms of traps it is the height of the column of water from the lowest point of the "tongue" or "dip" to the level of water in the trap (Figs. 89, 90, 100).

Forms of Traps.—Traps are of different forms in respect that they are fitted to different parts of the sanitary fittings and drainage-arrange-

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[1] The Drainage of Glasgow and Trapping of House-Drains, Glasgow, 1873.

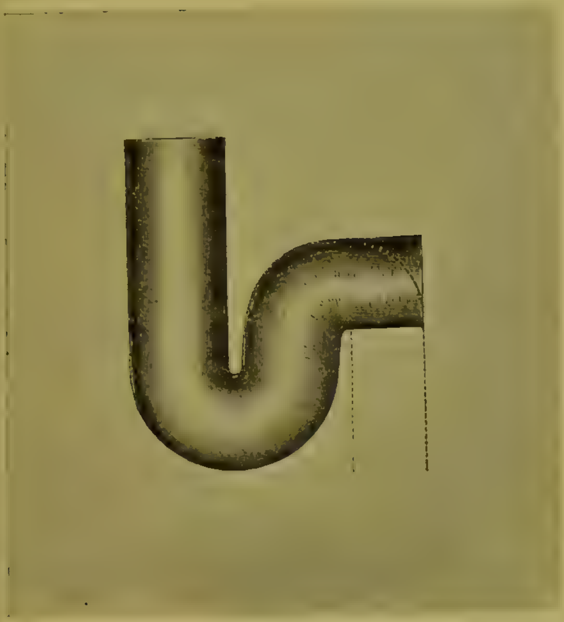

Fig. 89.—Ordinary S-Trap. The dotted lines complete the S-shape. Such a trap is fitted to kitchen-sinks, etc.

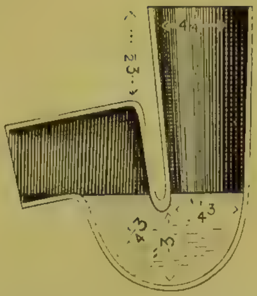

Fig. 90.—Anti-D Trap (Hellyer). The "water-seal" of the trap is the depth of the water-column between the level of the water in the trap and the point of the tongue on the upper surface of the bend.

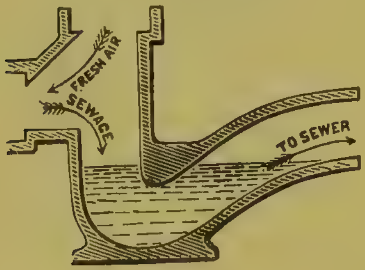

Fig. 91.

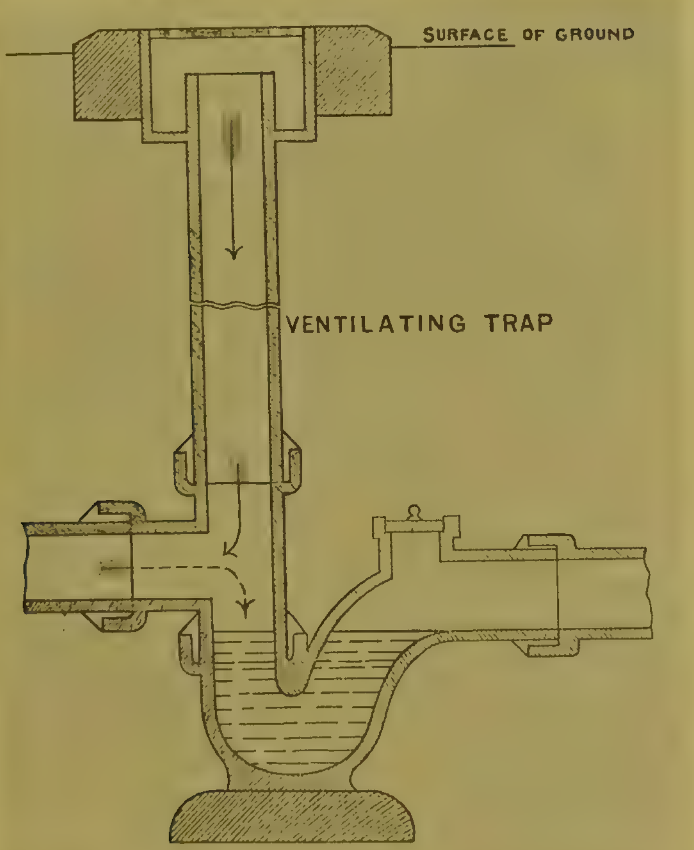

Fig. 92 shows Buchan's ventilating-trap with relation to ground-surface and flow of sewage. The ventilating-eye or opening of the trap is covered on the ground-level by a grated cover.

ments of a house and thus subserve different purposes. Those of baths and wash-hand basins consist of ꟃ bends in the pipe, with screw-plugs at the lowest part of the bend for cleansing purposes, and

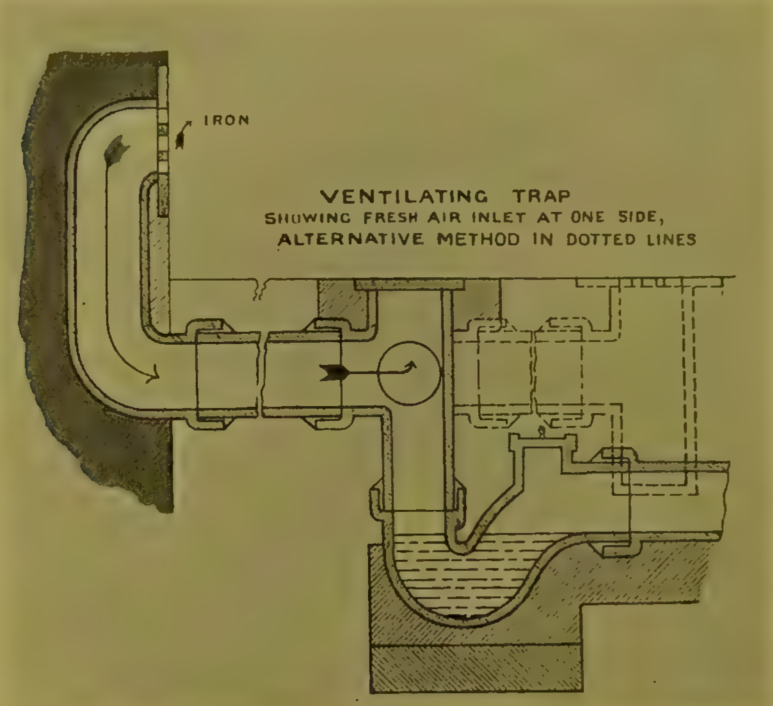
IRON
VENTILATING TRAP
SHOWING FRESH AIR INLET AT ONE SIDE,
ALTERNATIVE METHOD IN DOTTED LINES

Fig. 93.—To illustrate alternative Methods of Ventilating a Trap through which Fæcal Matter passes. The ventilating opening or shaft may be raised some feet above the ground-level when most suitable, as on the left of the Figure, or it may be permitted to open on the ground-level, as shown in the dotted lines.

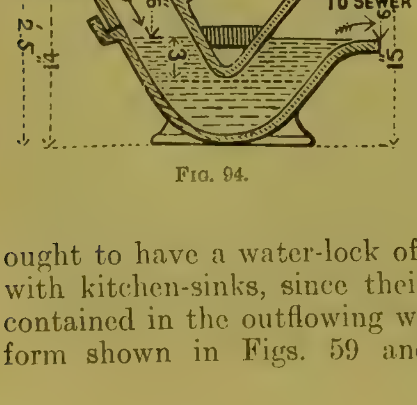

Fig. 94.

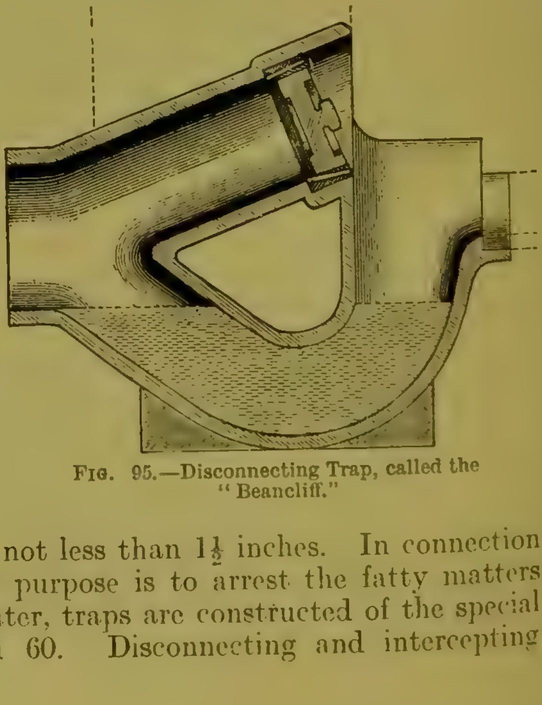

Fig. 95.—Disconnecting Trap, called the "Beancliff."

ought to have a water-lock of not less than 1½ inches. In connection with kitchen-sinks, since their purpose is to arrest the fatty matters contained in the outflowing water, traps are constructed of the special form shown in Figs. 59 and 60. Disconnecting and intercepting ventilating traps are fitted at the junction of waste- and soil-pipe with sewer, or at some point in the course of the house-drain. Fig. 92 represents one of the best forms of these, and Fig. 93, the same trap fitted to carry away the ventilating opening from a window or doorway. Gully traps, placed in court-yards, are constructed of forms intended to catch surface-water containing solid detritus, as well as to prevent outward passage of drain-gases. Many forms of traps have been made by many makers for many purposes, until their number has become legion. But their uses may be said to be confined to the above purposes.

Failure of Action of Traps.—Traps may fail in their purpose from one or other of the following causes, viz.: (1) from siphon action; (2) from momentum; (3) evaporation of water-seal from disuse; (4) from silting or sedimentation, due to imperfect position. Experience with traps in connection with pipes through which water flowed with considerable velocity showed that the water-seal was liable to be forced under certain conditions; and upon

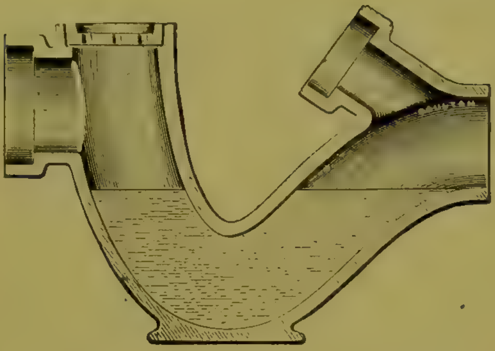

Fig. 96.—Weaver's Ventilating and Disconnecting Trap.

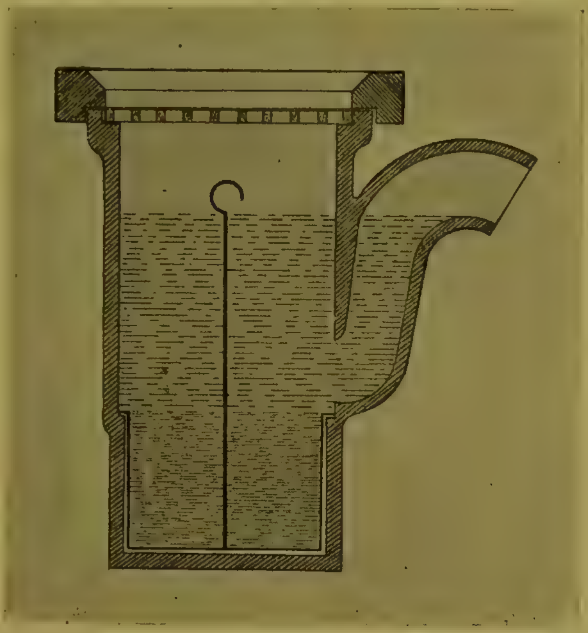

Fig. 97.—Dean's Yard Gully-Trap. It contains an iron bucket to receive the detritus, which can be emptied periodically by taking out the bucket by means of the handle shown in the Figure.

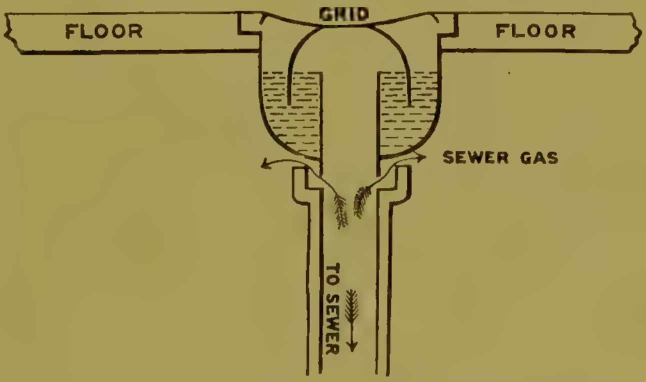

Fig. 98.—Bell-Trap—a very unsafe form of Trap, owing to the evaporation of the water unsealing the trap. It is still found in use in court-yards.

investigation it was found that the disturbing cause was either difference of atmospheric pressure on the two sides of the trap, or momentum—the combined effect of velocity and weight—of the flowing columns of water. Of the causes of failure above enumerated, probably the most common is siphoning. This very readily happens, indeed is only likely to happen, where the traps themselves or the main pipes are unventilated or imperfectly ventilated.

A valuable series of experiments bearing on the siphoning of water-closet traps has been made under the supervision of a Committee of the Sanitary Institute [1] upon apparatus fitted in the Parkes Museum. This apparatus consisted of a lead soil-pipe, 3½ in. in diameter, 30 feet 8 in. high, with two 3½-in. closet-branches, one 2 ft. 10 in., and the other 12 ft. 10 in. above the ground level, each branch having a 2-in. ventilating or anti-siphonage pipe fixed at a point 9 inches from the crown of the trap. These ventilating pipes were connected and carried 9 ft. 3 in. above the upper closet-branch, and were provided, as was also the soil-pipe, with valves for closing the pipes for the purposes of experiment. The closet basins were short hoppers with circular outlets, the outlet of the upper basin being 3¼ in. in diameter, that of the lower, 3½ in. in diameter. The traps used in the upper basin were (1) a cast lead "anti-D" trap, 3½ in. in diameter, with a water-seal of 2 in., and containing 40 oz. of water; and (2) a drawn-lead "Dubois" trap, 3½ in. in diameter, water-seal 2 in., contained water, 60 oz.; those used in the lower basin were (1) an "anti-D" trap, 3½ in. in diameter, water-seal 1⅞ in., contained water, 40 oz.; and (2) a "Dubois" trap, 3½ in. in diameter, water-seal 1⅞ in., contained water, 60 oz. The water used in the experiments was poured from a pail into the basin. (Fig. 99.)

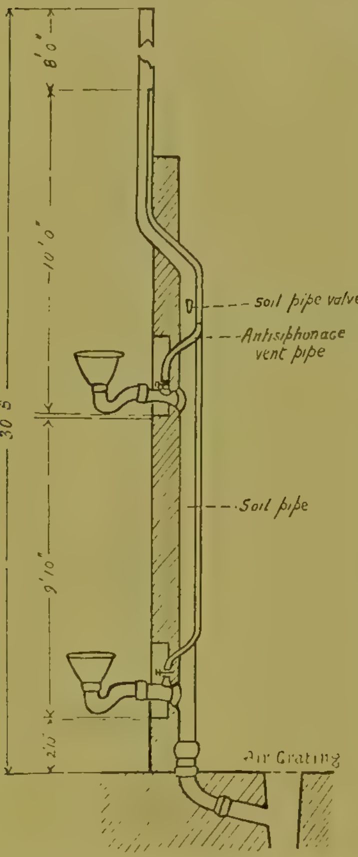

Fig. 99.—Drawing of Apparatus used in Experiments on the Siphoning of Closet-Traps, carried out by Committee of Sanitary Institute.

Four sets of experiments were made, viz.: (A) Water poured into upper basin, and effect produced on trap of same observed; (B) Water into upper basin, and effect on trap of lower basin; (C) Water into lower basin, and effect produced on trap of same; (D) Water into lower basin, and effect on trap of upper basin. These experiments were conducted under four sets of conditions, viz.: (1) The anti-siphonage pipe open and the soil-pipe open; (2) The anti-siphonage pipe closed and the soil-pipe open; (3) The anti-siphonage pipe open and the soil-pipe closed; (4) Both pipes closed. Under conditions A, B, C, D, and (1) neither of the traps were siphoned; under conditions A and (2), the "Dubois" trap was unsealed, and under conditions B, C, D, and (2) it was not unsealed, and under none of these conditions was the "anti-D" trap forced; under conditions A, B, C, D, and (3), both traps were intact; and under conditions A and (4) both traps were unsealed, but under conditions B, C, D, remained water-locked. It would appear, therefore, that these experiments but corroborate well-established facts, viz.: (1) that when the soil-pipe is open and a ventilating branch to the trap is provided, siphoning is prevented; (2) that if the soil-pipe be closed and no ventilating branch to trap be provided, siphoning readily occurs; and (3) that siphoning more readily takes place in the absence of a ventilating pipe to trap, although the soil-pipe be open.

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[1] *Jour. San. Inst.*, vol. xxii., part i., 1901, p. 88 *et seq.*

Momentum is another cause which tends to unseal a trap. When the descending column of water in a soil-track at its junction with the soil-pipe reaches an unventilated trap, it obviously has obtained considerable velocity, which is not much reduced by the water-seal of the trap; consequently, since it is difficult to bring a body moving at such velocity to a state of rest, when the last portion of the column reaches the trap, its contents are in violent agitation, and the column of water is likely to carry with it sufficient of the water of the trap to unseal it. *Disuse of traps* is another source of failure, by reason of evaporation of water-contents below the water-seal. This is liable to occur in the fittings of houses which are shut up in summer for several consecutive months, during which time the deposits in the soil-pipe and connections become also dried and powdery. By reason, therefore, of the inoperative effect of the traps in these circumstances, not only may foul gases but also pathogenic micro-organisms gain an entrance into living apartments, to give rise to attacks of illness of inmates, it may be, when the house is re-occupied. But a more common cause of this is where through carelessness, after alteration in position of certain sanitary fittings, the connections therewith have not been entirely removed but have simply been covered over. In such a case the entrance of drain gases is bound sooner or later to be effected. Traps may further fail in their duty from being improperly set, from the effect of which, in one case, the water-seal may be opened, or in another case, sedimentation of solid matter may take place in the trap itself. This latter may also occur from insufficient flushing or from insufficient gradient of house-drain. These conditions compel different remedies, some of which are obvious. Siphoning, however, is entirely prevented by free ventilation of traps and soil-pipe. A trap is ventilated by a pipe being put on the "crown" of the tap, that is, on the soil-pipe side of the trap Where a series of ventilating pipes are required by reason of a superposed series of fittings, as in tenement houses, they are either passed singly through the wall into the open air directly, or they are either united to a separate ventilating shaft, or joined separately to the soil-pipe at a distance above the entrance of each branch which is regulated (1) by the maximum flush of water which is discharged into the soil-pipe at one time, and (2) by the length of soil-pipe which that amount of water will fill. One gallon of water fills a 4-inch pipe length of 22 inches, and one of $4\frac{1}{2}$ inches diameter, a length of $17\frac{1}{2}$ inches; therefore, if the flush from a water-closet be three gallons and the size of pipe be 4-inch diameter, then $22 \times 3 = 66$ inches will be the height above the trap at which the ventilating pipe of that branch should be joined to the soil-pipe.

In the large disconnecting or intercepting traps made of fireclay or earthenware which are placed in the ground in some part of the course of the house-drain, ventilation is obtained by a special opening in the trap which reaches to the ground level, and which is of the same diameter internally as the soil-pipe or house-drain, in order to permit of free egress of air. This opening, which is on the reverse side of the trap, is usually covered by a grating. Such traps have usually four openings, viz.: (1) inlet for sewage; (2) outlet for sewage: these are horizontal openings; (3) ventilating opening; (4) cleansing or inspection opening. Of these two latter, which are vertical openings, the former is of a greater diameter and is always next to the inlet-opening,

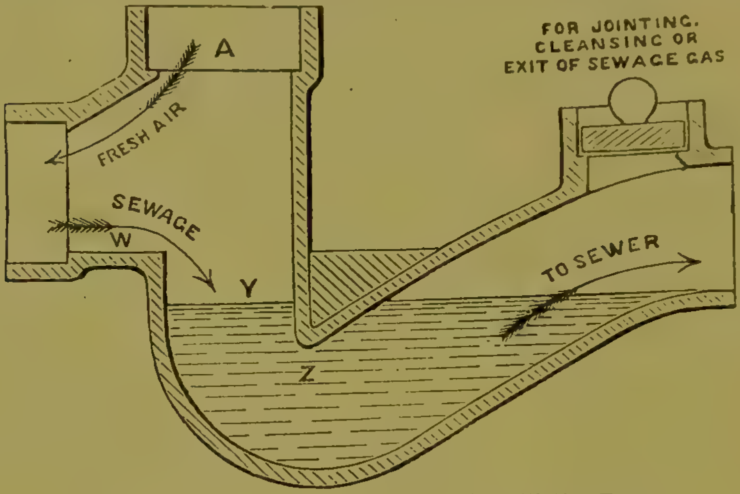

Fig. 100.—Buchan's Disconnecting and Ventilating Trap.

so that when the trap is placed in position in relation to soil-pipe and sewer, the ventilating opening is nearest the soil-pipe, that is to say, it is on the house side of the trap. This will be comprehended better by reference to Figs. 92 and 93. In order to prevent this ventilating "eye" opening near a window or doorway, an arrangement may be provided as in Fig. 101, where this ventilating eye is carried along for some distance from the trap.

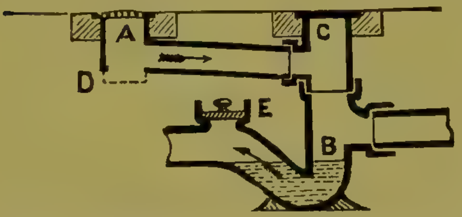

Fig. 101.—Showing mode of carrying ventilating opening of trap away from doors or windows.

The essential points of a good trap are the following, viz.: (1) it should be of a self-cleansing shape; (2) it should have an opening equal in internal diameter to that of soil-pipe for ventilation; (3) it should possess a water-seal of not less than 2 inches; (4) it should be set in a perfectly level position; (5) it should possess an opening for inspection or cleansing purposes.

Is the Use of Traps Over-done?

The time has now fully arrived for a re-consideration of the whole question of trapping of fittings and of intercepting drain-traps. Many years of experience of these fittings enables a judgment, based upon experience, to be formed on the question whether so many, indeed, if any, intercepting traps are needful in an otherwise sound and well-constructed domestic drainage system. An intercepting ventilating trap placed at some point between the entrance of a main soil-pipe or waste-pipe serves one very useful purpose at least—viz. as a convenient point from which a smoke-test may be applied to that part of the domestic drainage which it controls. On the other hand, seeing that one of the chief objects of domestic sanitation is to get rid quickly of polluted fluids from the house to the sewer, this is in some measure frustrated by the presence of an intercepting trap between the main exit foul-pipe and the house-drain and sewer, because the velocity and momentum of the outward-passing volume of polluted liquid receive a check in progress of the liquid toward the sewer. The ideal method of dealing with the soil-pipe and waste-pipe is, when circumstances permit, to join them in an intercepting chamber placed on the house-drain between the house and the sewer and controlled by a single trap. Instead of this, however, the common practice is to control each main exit-pipe from a house by its individual disconnecting and ventilating trap. But as houses are built aligned on streets, the ideal method is hardly attainable, since the roadway is so frequently, and sometimes so fully, occupied by other pipes and channels than the sewer. The main object of the intercepting trap as originally conceived was to prevent the passage backwards from the sewer and house-drain of gases into the interior of the house, owing to what must now be considered an exaggerated fear of the possible and likely dangerous consequences of sewer-air and sewer-gases. Such consequences are, however, mainly, if not indeed entirely, averted by free ventilation of sewers, drains, and house main-pipes. Probably it would be true to say that the principal methods of ventilating sewers of our chief towns still consist of grid openings on the surface of the roadway : it is, perhaps, the exception to find ventilation of sewers achieved by special shafts or by works' chimneys. The same method might be applied to house-drains. This would ensure avoidance of air-tension within the drains from whatever cause that might possibly arise, and, besides, the drain and the domestic exit-pipes would be equally well flushed by air as by the ventilating eye of an intercepting trap.

So long as each fitting within the house is provided with an efficient trap, it does seem unnecessary to place in the ground an intercepting ventilating trap at some part between the junction of each main exit-pipe and the house-drain merely to prevent the possibility of foul air getting back into the soil-pipe or waste-pipe, as the case may be. Our experience and observation have led us toward the view that many of the intercepting traps now placed in systems of domestic drainage are not only unnecessary, but that they actually thwart the *raison d'être* of a well-planned system whereby quick exit of sewage from house to sewer is intended.

The London County Council in their bye-laws say upon this subject, that an owner " shall so construct such soil-pipes that there shall not be any trap in such soil-pipe, or between the soil-pipe and any drain with which it is connected."

Most bye-laws of other populous places enact that an intercepting trap shall be placed at some point in a system of house-drainage between the soil-pipe and the sewer.

The keynote of the position with regard to safety lies in efficient house-fittings suitably trapped and sound soil-pipes well ventilated.

Flushing of Drains.—If house-drains are properly laid, the velocity of outgoing sewage and waste-water ought to be sufficient to keep the channel free of sediment. If the house-drain be larger than required, that is to say if a 6-inch pipe has been put where a 4-inch is sufficient, sedimentation may occur, but if the proper fall corresponding to the size of the pipe has been adopted, even in such a case there is little likelihood of silting taking place. In some places, the waste-water is utilised for the purpose of flushing by being stored in a tank, which when filled to a certain point and by reason of its being suspended on a swivel, turns over and forcibly empties the whole contents into the drain. To flush a drain properly it is necessary to project suddenly into it such an amount of water as will cause it to run full-bore; it is futile to attempt this by the running of a tap or a series of them.

Testing of Drains.—While it is of importance in the case of newly-built houses that before occupancy the integrity of all the fittings for the drainage of a house should be tested and assured, it is of even greater importance that, at least annually, the test of efficiency should be repeated. Systematic attention to this would avert much disease. The modes by which fittings and house-drains are tested are these, viz.: (1) The hydraulic test; (2) The pneumatic test, (*a*) by smoke under slight pressure, and (*b*) by air itself under a higher pressure; (3) By putting some volatile odorous substance into the drain-system.

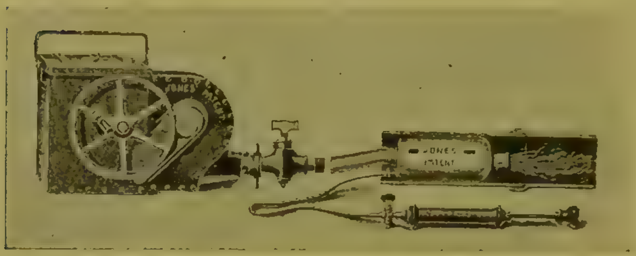

FIG. 102 represents Jones' Machine for applying the Smoke-Test to Drains. By means of the hand air-pump lying in front of the Figure, the bag inserted in the Drain is inflated, and the drain thus made air-tight. The Bag is constructed so that the smoke-pipe from the machine passes through it into the Drain, and so the Drain or Pipe may be filled with smoke.

The hydraulic test is a very severe test, and when applied to pipes in the vertical position is a most unequal test, since the point of greatest pressure is the lowest, from which the pressure becomes gradually less until the highest point is reached where the amount of pressure is practically nothing. It is a much fairer test when applied to pipes in a nearly horizontal position, as a house-drain. In America, however, where waste- and soil-pipes are placed on the inside of the wall of the dwelling because of the severity of the weather in winter, special precautions are taken to secure their integrity. The pipes are heavy cast-iron pipes with leaded joints, and each length is tested by the hydraulic test when placed *in situ*. In this way, by regulating the size of length to be tested, not only may each part of the whole be tested, but a fairly uniform pressure may be used upon each part. To this

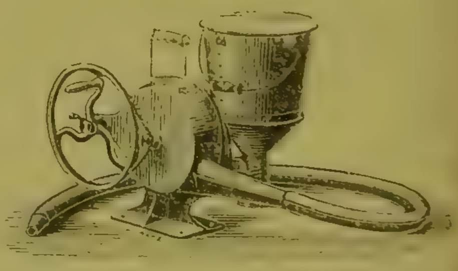

FIG. 103.—Another form of Smoke-testing Machine.

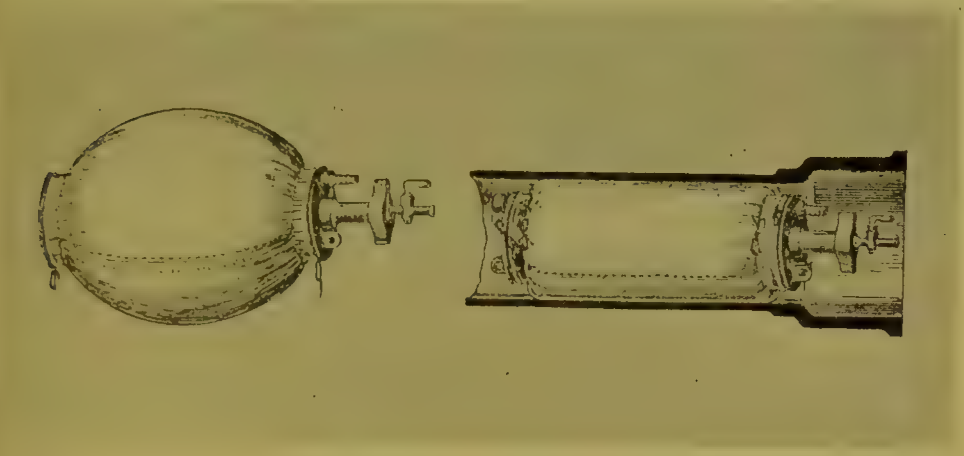

Fig. 104.—Bag Drain- or Pipe-Stopper for testing Drains or Pipes by smoke, pneumatic, or hydrostatic test. (Burn Brothers' Patent.)

mode of testing vertical pipes there can not only be no objection offered, but there is, on the other hand, much to commend its use in this country. The test consists in stopping the sewer end of the house-drain with an expanding rubber-rimmed plug, and filling the whole length with water. Should the level of the water in the trap—the point of observation—fall, it indicates faulty construction, provided that no leakage is occurring at the point of plugging. The pneumatic test by smoke can be applied to most buildings at any time. It consists in filling the whole sanitary apparatus with pungent smoke generated from sulphur and oily waste cotton, under some degree of pressure. The amount of pressure, however, is very small, but is sufficient to reveal substantial flaws in piping which are difficult of detection by simple inspection. In order to conduct the test it is necessary to hermetically close the top openings of waste-pipe and soil-pipe, where the waste-pipe is connected underground with the house-drain by means of a trap. The smoke is driven into the ventilating opening of the trap, which is closed by clay round the inlet smoke-pipe from the smoke-generating apparatus. In the event of there being any points of leakage in pipes or fittings, the presence and odour of smoke at these points will indicate them. The

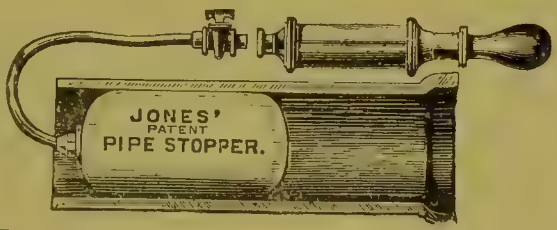

Fig. 105.—Pipe-Stopper inflated by air-pump to close drain-pipe.

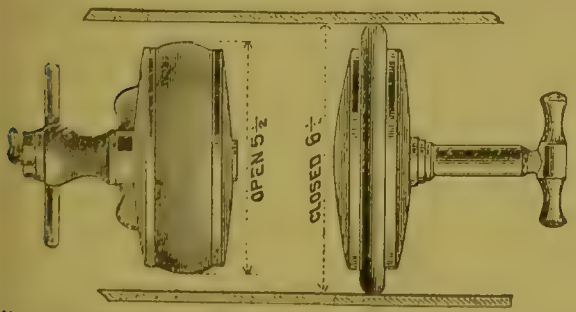

Fig. 106. Jones' expanding Screw for Stopping Drain or Pipe, in smoke, pneumatic, or hydrostatic test.

apparatus used is called a smoke-testing or fumigating machine, and it consists of the following essential parts, viz.: (1) The motive power by which the smoke is propelled into the house-fittings; (2) The smoke-generating receptacle; (3) Rubber-tubing to connect these, and also to connect the latter wtih the ventilating opening of trap. The motive-power in most machines is by hand-working a fan which propels the smoke, but in Fyfe and Dobson's apparatus the motive-power is the automatic action of spirting jets of water.

By means of a side-opening, the Fyfe-Dobson apparatus is connected with the service water-pipe from the main-pipe. When the jet of water enters the cone-shaped part, in the upper part of which the smoke-generating material is placed and lighted, it is split into a large number of fine spirts or sprays, which cause a current of air and smoke to be propelled into the drain to be tested. The advantages of the machine are its saving of hand-labour, its automatic action, and, depending upon the pressure of the water-supply, a higher smoke-pressure.

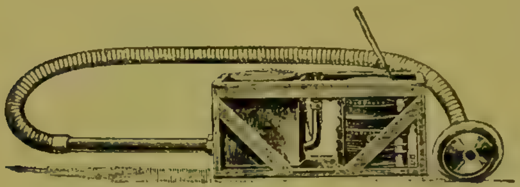

Fig. 107.—Smoke-Testing Machine. On the right is the bellows, and on the left the smoke-generating receptacle, out of which passes the tubing for connecting the whole apparatus with the drain attachment.

The main objection urged against the smoke-test is that the pressure of the smoke is insufficient to detect such defects in pipes or fittings as will emit foul air, either from defective workmanship, or from defective material; in other words, that although on application of this test no leakages are discovered, it is no certain proof of the tightness of the drainage-system. Another objection is that unless the leakage is substantial, it is apt to be overlooked by the careless observer, since minute inspection of each pipe and fitting during the currency of the test is necessary and essential. For these reasons, therefore, it has been strongly urged to substitute air under compression for smoke. The advantages and merits of the air-test urged by its advocates are these: (1) It gives a positive result; (2) it can be applied to any building and the pressure be made uniform; (3) it can be applied to covered or uncovered pipes; (4) it is

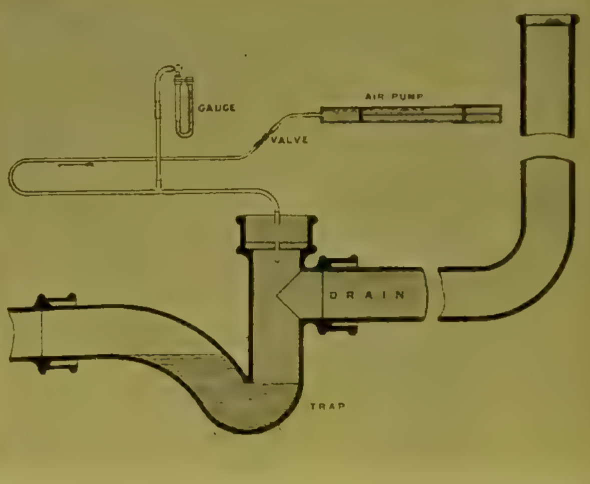

Fig. 108 shows Gilbert Thomson's Mode of Testing Drains by Pneumatic Pressure. By means of the air-pump any air-pressure, up to a reasonable amount sufficient to test the integrity of workmanship and material, may be employed. The amount used is indicated by the manometer or gauge. By the steadiness or fall in level of the manometer is the integrity or faultiness of the fittings determined.

easy of application ; (5) the pressure can be regulated from a fraction of an inch of water up to a number of feet of water ; (6) leakages are discovered by a fall occurring in the manometer at the point of operation. Against its use, it has been urged that although leakages may be proved to exist, they are more difficult of detection because there is no visible or olfactory evidence of their location as in the smoke-test, and therefore, in the end, recourse must be had to the smoke-test. To Gilbert Thomson of Glasgow must be ascribed the merit of introducing and showing the value of the pneumatic test as a proof of substantial workmanship and excellence of quality of material. The apparatus which he has devised for the test may be described as follows : —It consists of (1) an air-pump ; (2) a valve ; (3) a manometer or gauge ; (4) a brass ⊢-piece ; (5) some yards of rubber-tubing. By using water in the manometer pressure up to four inches, and by using mercury, a pressure of 4½ feet of water may be attained. Defects in the sanitary fittings are betrayed by the falling of the manometer on the pumping-in of air being stopped. (*Vide* Fig. 108.)

The use of odorous substances, such as oil of peppermint followed by hot water, has been advocated for buildings of old standing in the drainage system of which there is no disconnecting trap or chamber. Apart from the inefficiency of such substances to detect any other than very substantial or gross flaws, the very fact that no disconnecting apparatus exists ought of itself to condemn the system as insanitary and dangerous to health. In such a case the drain should be opened and the smoke-test or pneumatic test applied after a disconnecting trap has been introduced.

Plan of Drains.—The Public Health (Scotland) Act, 1897, section 181, gives power to Local Authorities to make bye-laws respecting the production of plans with reference to the proposed system of drainage of new buildings. Glasgow, Aberdeen, Dundee, Greenock, and local authorities of other burghs demand the production of such plans to scales laid down. A good scale is that adopted by Aberdeen, viz. : ⅛-inch to the foot. Section 120 of the aforementioned Act, and s.s. 238 and 239 of the Burgh Police (Scotland) Act, 1892, enact that no building shall be erected until a sufficient drain or sewer has been constructed from a common sewer to a point opposite the proposed building, provided that a common sewer exists within 100 yards of the proposed building, or until the Local Authority is satisfied that a proper channel for sewage can and will be provided. An exact plan of the drainage-system of every occupied building should be possessed by the owner. Such plans at first sight seem complicated ; but they may be quickly understood. Much unnecessary expense and trouble are saved by such plans (*vide* Figs. 78, 83).

Disinfection of Drains.—It is neither simple nor easy to disinfect, in the true sense of the word, a drain, and much less a sewer. To achieve scientific disinfection would be both laborious and costly. The fashion of adding disinfectants in small quantities is simply a delusion, because of the degree of dilution which these undergo. Certain disinfectants as corrosive sublimate, chlorinated lime, and others, which are passed into soil-pipes with this object, attack the metal of the pipes, the first acting especially as a solvent of the solder. The best and cheapest disinfectants, which, moreover, are secured by efficient ventilation of traps and pipes, are fresh air and a plentiful supply of water. If all channels are well flushed with both of these, there is no need for attempted chemical disinfection.

Before leaving the subject of house-drainage, the term "house-drain" ought to be defined in order to distinguish between that channel and the sewer. A house-drain may be said to be that channel which receives the waste-water, rain-water, and excretal products from one building; the sewer, that channel which receives these products from several buildings by way of the house-drains. It is for this reason that in Scotland the sewer is usually called the *common* sewer. The Public Health (England) Act, sec. 4, defines a drain as "any drain of and used for the drainage of one building only, or premises within the same curtilage, and made merely for the purpose of communicating therefrom with a cesspool or other like receptacle for drainage, or with a sewer into which the drainage of two or more buildings or premises occupied by different persons is conveyed"; and a sewer, as including sewers and drains of every description except drains to which the word "drain" interpreted as above applies, and except drains vested in or under control of any authority having the management of roads and not being a Local Authority under this Act. In the Metropolis Local Management Act, 1855 (18 & 19 Vict. cap. 120, sec. 250), the word "drain" is held to "mean and include any drain of and used for the drainage of one building only or premises within the same curtilage, and made merely for the purpose of communicating with a cesspool or other receptacle for drainage of two or more buildings." In Pilbrow *v.* St. Leonard's Vestry, Shoreditch (*Times*, Nov. 3, 1894), the question in dispute was whether, in artisans' dwellings consisting of two blocks of forty-six sets of apartments draining into a common drain by twelve branch-drains, the common drain was a drain or a sewer in terms of section 250. The Court held that the "common drain" was a drain and not a sewer, and that the premises were one curtilage. There is no definition of drain or sewer in the Public Health (Scotland) Act, 1897, or in any other Public Health Act relating to Scotland. In the Glasgow Buildings Regulations Act, 1900, "drain" means any drain or pipe which connects the waste- or soil-pipes or conductors of a building or buildings with a sewer or cesspool.

Sewers.—These channels which receive the sewage from the drains of houses, and, usually also, the rainfall, street-washings, and effluents from trade processes, commonly run in the centre of the street or roadway. They are like the veins of the circulatory system, in respect that their size becomes larger as the outfall is neared. In any particular case, the sewer must not only be made large enough to carry away a present total estimated amount of sewage, but also to include a future possible increase. Their shape is either round, oval, or egg-shaped, the best shape being the last-named, since it offers the minimum amount of friction to velocity of flow, and as the volume of flow becomes diminished this resistance is proportionally reduced, whereas in the circular form, on reduction of volume of flow the resistance is relatively increased. The smaller-sized sewers are now constructed of glazed fireclay, and of egg-shape, the larger of brick smooth-lined and of like shape.

The points to be aimed at in the construction of sewers are as follow : (1) To ensure uniform and constant velocity of flow ; (2) To secure by sufficient gradient such velocity of flow as will remove solids but will not unduly wear brickwork of sewer ; (3) To prevent sedimentation and deposition of solid material at junctions ; (4) To minimise back-watering as much as possible at the outfall on tidal rivers ; (5) To secure by ventilation the greatest possible purity of air of sewer ; (6) To prevent by like provision the forcing of house-drain traps or other traps of houses. The velocity of flow in sewers should not be less than 2 or 3 feet nor more than 4 to 5 feet per second, because such mean velocity will effect removal of solids without undue prejudice to brickwork. The fall in sewers should be 1 in 240 ; where the gradient is less, deposits are apt to form. It happens, however, in exceptional circumstances that such a fall as the foregoing cannot be obtained with relation to the position of the most suitable place for disposal of sewage into the sea or for purification. In Brighton, for example, the fall is only about 3 feet per mile, or 1 in 1760. In other districts still more level, and where a proper sewer gradient cannot be obtained without very deep cutting or tunnelling, it is better and cheaper to adopt the Shone system, in which by means of his patent ejectors worked by compressed air, from a central station, the sewage is lifted from one level to another, each section of sewering being laid with a proper fall, thus utilising all the assistance which gravity is able to give. The ejector is a cylindrical reservoir having an inlet and an outlet pipe for the entrance and exit of the sewage, each pipe being provided with a ball valve, and the inlet pipe having the shape of a siphon. By means of tubes which are conducted along the upper flat surface of the exterior of the reservoir, compressed air is injected by the automatic action of a float on a counterpoised lever which opens the air-valve. This float rises as the reservoir fills with sewage, and at a given height sets this mechanism in operation. The effect of the admission of compressed air is to close the inlet valve, liberate the outlet ball-valve, and to drive or eject the sewage out of the reservoir by means of the outlet pipe into the section of sewers at a higher level, by which it flows by gravity into the next ejector, and so on until the outfall is reached. It is claimed for the process that two such ejectors, each of a capacity of 100 gallons, are separately capable of raising 75 gallons of sewage to a height of 50 or 60 feet, and that they suffice for the convection of the sewage and rainfall of an area of 2000 inhabitants. This system has been in operation since 1896 in Arad, Hungary, and disposes of the sewage of 20,000 persons by means of five ejector stations ; also in Eastbourne, Southampton, Warrington, and in Cape Town and Rangoon.

Flow in Sewers.—There are certain terms and equivalents used in hydraulic formulæ with which the student ought to be acquainted.

P=Pressure in lbs. per square inch.
H=Head or column of water in feet.
V=Velocity (theoretical) in feet per second.
G=Gravity = 32·2 ft. per second.

Pressure in lbs. per square inch = H × ·4335.
Head of Water = P × 2·307.
Pressure in lbs. per square foot = H × 62·425.

One cubic foot of water = 62·425 lbs. = ·557 cwt.
One „ inch „ = ·03612 lb.
One gallon of water = 10 lbs. = ·16 cubic foot.
One cubic foot of water = 6·24 gallons = $6\frac{1}{4}$ gallons.
One cwt. of water = 1·8 cubic feet = 11·2 „

$$V = \sqrt{2G} \times \sqrt{H}.$$

$$H = \frac{V^2}{2G} = \cdot 0155V^2. \quad \frac{1}{2g} = \cdot 0155.$$

1. To find the velocity of any given head of water:
   Multiply the square root of twice the gravity by the square root of the given head.

Example: If an 18″ pipe at a gradient of 1 in 900 gives a velocity of 2 feet per second, what would the velocity be if the gradient were changed to 1 in 100, the pipe running half-full in each case? Here, the only factor that is changed is the difference in gradient—viz. from 1 in 900 to 1 in 100, or 9 in 900. Velocity varies as the square root of the inclination, other things being equal:

$$\therefore \sqrt{9} = 3. \quad \therefore 3 \times 2 = 6 \text{ feet per second.}$$

2. To find the fall required to give a certain velocity.

Example: If in a 6″ circular pipe with a fall of 3 inches in 10 feet the velocity is 5·5 feet per second, what fall will be required to produce a velocity of 11 feet per second?

The fall must be in the ratio of the squares of the given velocities.

A fall of 3″ in 10 feet = 1 foot in 40 feet.

$$\therefore 11^2 : 5{\cdot}5^2 :: 40 \text{ feet} : x;$$
$$= 121 : 30{\cdot}25 :: 40 \text{ feet} : x$$
$$= 4 : 1 :: 40 \text{ feet} : x$$
$$= x = 10 \text{ feet: or a fall of 1 in 10 feet.}$$

Hydraulic Mean Depth.—This term means the depth of a rectangular channel whose sectional area, and therefore the volume of whose current, equals that of a curvilinear channel under consideration, and whose width equals the entire wetted perimeter of the latter; put more shortly, it is the sectional area divided by the wetted perimeter.

For a circular pipe (running half-full) $= \frac{\text{area}}{\text{circumference}}$;

or $\frac{\pi r^2}{2\pi r} = \frac{r}{2}$: Hydraulic mean depth is half the radius.

Calculation of Discharge from Sewers.—Various formulæ are employed for this purpose, but we only adduce two of these, viz.:—

Eytelwein's formula. $V = 55 \times \sqrt{D \times 2F} \times A$ = Discharge in cubic feet per minute.

Fleeming-Jenkins' do. $V = 92{\cdot}67\sqrt{F \times D} \times A$ = Discharge in cubic feet per minute.

V = Velocity in cubic feet per minute.
D = Hydraulic mean depth.
F = Fall in feet per mile.
A = Sectional area of fluid current in channel.

First, ascertain values of D and F.

D = One-quarter of the diameter of circular pipe if running full; if not full, it is the sectional area divided by the wetted perimeter.

For egg-shaped sewers, it is—

(*a*) Sewer running full bore = Transverse diameter $\times \cdot 2897$

(*b*) „ „ two-thirds full = „ „ $\times \cdot 3157$

(*c*) „ „ one-third full = „ „ $\times \cdot 2066$

F is found by estimating the fall in a measured distance of 100 or 200 feet and calculating in terms of 5280 feet per mile.

In the newest form of sewer, the vertical height is equal to one and a half times the transverse diameter, and the radius of invert to one-eighth the transverse diameter.

Planning of Sizes of Sewers.—In estimating sizes of drains and sewers in a sewerage-system, engineers are guided by certain practical rules derived from the combined results of observation and experience. These are formed for separate units and for combinations of units of area, these sometimes being spoken of as the separate system and the combined system respectively, although erroneously as will be considered later.

In the separate unit area the factors to be taken into account, based upon averages, are three in number—viz. (*a*) rainfall per head per day, (*b*) water-supply or sewage per head per day, and (*c*) average number of units per family. The allowance made for (*a*) is 15 gallons, for (*b*) 25 gallons, and for (*c*) five; thus giving a total of 200 gallons per family per day to be removed.

In the combination of units area there are also three factors to be considered—viz. (*a*) the area built over and the area of road; (*b*) the maximum rainfall of the district reckoned at the highest recorded rate per hour, and (*c*) the sewage per head for total inhabitants of combined areas.

From these factors, with a reasonable allowance of margin, the highest total possible volume of sewage at different points of the sewerage-system may be calculated, and from these possible volumes the respective sizes of sewers to be provided.

The Local Government Board requires that all sewers on the separate system shall be constructed of such a size, etc., as to be able to discharge six times the dry-weather flow when running full. Thereafter storm-water overflows come into operation and discharge the excess into water-courses. The dry-weather flow of sewage is usually reckoned as the volume of the water-supply per head multiplied by the total number of inhabitants within the area sewered, the former being taken in the average place as 25 gallons per head per day. Hence $25 \times 6 = 150$ gallons, the amount to be provided for per inhabitant in sewers before the storm-water overflows come into action.

Ventilation of Sewers.—In some populous places, as Bristol, the sewers are unventilated; and it is alleged that the only time when complaints of smells arise in that city is after prolonged drought when the gully-traps become dry. Statistical evidence of those diseases attributable to sewer influence shows no excess of mortality in that city. In most towns and cities, however, the sewer-system is ventilated by means of gratings situated in the roadway, while in a smaller number of populous places special ventilation-shafts are substituted for the gratings. Ventilation into mill and other public works' chimneys has been tried in such places as Burton, Bradford, Hull, Leeds and Gloucester. But this plan, so far as it has been examined, is not held to be satisfactory. It is said that in the three last-named towns the air of the sewers is not affected beyond 200 yards from the chimney. In the Brighton system, the main outfall-sewer, and to some extent the town-sewers are ventilated by means of a furnace and tall chimney placed at the outfall. The gratings referred to are placed at distances of from 40 to 100 yards apart, and there is little doubt that an interchange is effected between the air of the sewer and of the outer atmosphere. The ventilating action is, however, fitful and variable; some of these gratings act at one time as outlets, and at others as inlets, while at another time their action respectively is reversed, the incidence of their action depending upon local air-movements, and the admission of hot water or spent steam at given points into the sewers. There can be no doubt that ventilation of sewers is necessary, but the best plan to attain this can only be decided by local circumstances. Whether the time will come when the sewer-system of towns and cities will be ventilated as carefully as the interior of inhabited dwellings, hospitals, or other large buildings, it is difficult to say, but there is no doubt that the present mode of ventilating into streets and roadways exercises prejudice, in some measure, to the public health. It would be an infinitely superior method to the roadway gratings to ventilate by tall shafts placed at suitable points, from which a current of air could be drawn through the sewers by the motive power of a furnace and tall chimney erected at the outfall-works.

Sewer-Air and Sewer-Gases.—It is universally admitted that the respiration by persons of an atmosphere containing an admixture of sewer-air and sewer-gases is productive sooner or later of illness. Since drains and sewers carry fluids in an active state of decomposition, foul-smelling gases, consisting chiefly of compounds of sulphur with hydrogen or ammonia, are bound to be given off. That the inspiration of air largely contaminated with these gases is fatal to human life has been proved on not a few occasions in London, Glasgow, and elsewhere, by deaths of workmen in sewers. From constant exposure to much smaller quantities ill-health is occasioned, as shown by loss of appetite, malaise, debility, anæmia, and, sometimes, by eruptive skin-diseases, as boils, etc. The composition of sewer-air obviously depends upon the measure of free ventilation which exists, and this factor must be held to account for the great differences found in analyses of such air. Reduction in volume of oxygen and increase in volume of carbonic acid and hydrogen sulphide seem to be the outstanding characteristics of sewer-air, and the respective amounts of these would appear to depend upon the ventilated or unventilated condition of the sewer from which the air-samples are drawn. In addition, however, to these malodorous gases, there are others which possess a faint, sickly, or fetid odour, and which appear to be composed of compounds of carbon and ammonia and carbon and hydrogen. Of greater importance, perhaps, than these, are the micro-organisms of sewer-air of the pathogenic type.

Much information on the subject of sewer-air investigations may be obtained from the reports by Parry Laws, F.I.C., to the Main Drainage Committee of the London County Council in 1892 and 1893. He quotes the results of Carnelly and Haldane's observations on the air of the main sewer of Westminster Palace and in various sewers in Dundee, which mainly were as follow :—(1) that the amount of CO_2 was about twice and the organic matter about three times as great as in the outside air at the same time ; (2) that the number of micro-organisms was less in sewer-air than in the outside air at the same time ; and (3) that sewer-air contained a much smaller number of micro-organisms than the air in any class of house they had investigated, and was in a very much better condition than the air of naturally ventilated schools, and, excepting the amount of organic matter, than the air of mechanically ventilated schools.

Laws' own results were to the following effect :— (1) that the micro-organisms in sewer-air are related to the organisms in the air outside and not to the organisms of the sewage ; (2) that in the air both within and without the sewer the forms of organisms present are almost exclusively moulds and micrococci, whereas the organisms of sewage are for the most part bacilli ; and (3), though not warranted by any evidence, that it is quite conceivable that the danger of sewer-air in its causal relation to disease is an indirect danger.

Arthur[1] disagrees with these views. He showed that at a sewer-ventilator with an in-going current of air the number of organisms was greater than in the outside air, and he claims to have found *M. ureæ*, along with either *B. coli communis* or *B. typhosus* in sewer-air.

Delépine's investigations on the influence of sewer-air upon health, conducted at the instigation of the Corporation of Manchester during 1908, indicated that the air of a well constructed sewer carrying moderately dilute average sewage is free from appreciable noxious properties, but that in the case of a sewer in which sedimentation of excretal matters has taken place, or of those in which certain kinds of trade effluents and waste products are carried, noxious gases deleterious to health are likely to be given off.

Despite, however, the researches of Laws and Andrewes and others on the micro-organisms of sewage and sewer-air, micro-organisms of disease must sometimes pass from sewers with the air. It is established that air cannot take up organisms either from a column of liquid or from a wetted surface, but it is equally well proved that air can dislodge them from a desiccated surface, else conclusions respecting air-borne infection of tuberculosis from dried sputum are wide of the mark. Therefore after long periods of drought, when the upper sections of sewers become dry, it is not difficult to conceive that bacilli and spores might be carried in the sewer air. This question demands still further investigation over long continuous periods before dogmatic conclusions can be formulated. It is difficult to disassociate in the mind as cause and effect the continued ill-health of families in houses, as exhibited by sore throat, diphtheria, and enteric fever, and the discovery of a corroded and perforated soil-pipe in the interior of the dwelling. Further, it has often been remarked in populous centres that filth diseases are less prevalent in a wet than in a dry summer and autumn. While, doubtless, other factors have an influence in the causation of these, the effect of dry-walled sewers cannot be left entirely out of count.

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[1] *Congress Instit. Pub. Health*, 1894.

Mode of Conducting an Investigation into the Sanitary Efficiency of a Dwelling.—This resolves itself into different lines of inquiry, depending upon the scope or limits of the investigation and the objects for which such an inquiry is demanded. If the object of the inquiry is whether a house, or part of a tenement building is or is not fit for human habitation, attention must be devoted to (*a*) ***structural deficiencies,*** in the form of dilapidation of walls, ceiling, floor, the presence of dampness, etc.; (*b*) ***deficiency of light***; (*c*) ***absence of means of ventilation*** and the impossibility of establishing through ventilation in underground rooms; and (*d*) ***absence of adequate arrangements for disposal of night-soil and household waste.*** Where, on the other hand, the object is to discover the integrity of the sanitary fittings in connection with a water-carriage system of disposal of sewage, a more restricted line of investigation is called for. In the first place, each sanitary fitting and its connections within the dwelling must be inspected to see if each possesses a suitable trap, and in the case of the closet-fitting, whether the water-flush is sufficient or not, and what is the form of the closet relative to efficiency. It is important at the same time to note the condition of the water-closet apartment with respect to possibility of ventilation and its position with relation to the other apartments. Thereafter the external fittings should be inspected so far as is possible from the ground-level. The points to be noted are: (1) whether or not the soil-pipe is carried for at least a distance of three feet above the eaves, and its position relative to windows; (2) whether the waste-water system is separated from the soil-pipe system; (3) the mode of connecting main waste-pipe and soil-pipe with house-drain, and the presence or absence of traps at or near the points of junction; (4) the general plan of drainage and course of drains. Thereafter, the integrity of the pipes and fittings must be tested either by the smoke- or pneumatic test. The effect of both tests has been already described, but the mode of applying the smoke-test must be explained more fully. The first step to be taken is to cover the upper extremity of the soil-pipe with a slate luted with clay, so as to make it air-tight, and also the upper end of the main waste-water pipe, if both main pipes be controlled by the same trap beyond their junction with the house-drain. Then the ventilating eye or opening of the disconnecting trap is uncovered, and the exit-pipe of the smoke-generating machine is fitted into it, and luted well round with wet clay so as to make it also air-tight. When this is accomplished, smoke is driven into the pipes until they are completely filled under some pressure, as shown by its presence in the upper extremity of the soil-pipe or waste-pipe on momentary removal of luting material. At this stage each apartment in which a fitting is placed—bath, sink, wash-hand basin, water-closet, or urinal—is examined for the odour or appearance of smoke, and the soil-pipe and waste-pipe on the outside wall are scanned for evidences of emission of smoke, and if such be found, they are noted. In the event of neither odour nor appearance of smoke being discoverable in any of the apartments, and if no smoke be seen to issue from the main-pipes *after careful examination*, it may be reckoned that no definite breach of pipes exists. If, on the other hand, odour of smoke be discovered in any of the apartments, careful search must be instituted until the source of leakage is discovered. Thereafter, the deficiency must be remedied. The pneumatic test is more searching, however, than the smoke-test, and it is calculated to discover not only definite breaches in the pipes and defective workmanship, but also defective material which might not be detected by the smoke-test. The advantage of this test over the other is that varying degrees of testing-pressure may be employed. The mode of application is exactly the same as the other, and so is the place where the air-pump is applied. Leakage is indicated by the gradual lowering of the pressure in the manometer, and the degree of defect in the pipes by the rapidity in fall of the pressure, or by the pressure-gauge refusing to rise. The practical difficulty, however, now arises as to the situation of the leak or leaks, which, obviously, can only be discovered by the hissing or sibilant sound which air escaping under pressure from a small opening is likely to cause. This, however, is likely to be absent where, for example, defect in the internal structure of a cast-iron pipe, such as defects in casting, is the only cause of the lowering pressure. In such cases, the smoke-test would be of little value, because the pressure is insufficient in ordinary circumstances to reveal the defect. It may happen, however, that the cause may be found in minute defects of joints, or in pin-hole openings in the continuity of pipes, or in cracks at bends. The sanitary fittings of a dwelling ought to be so perfect when first installed that they will stand some inches of pressure by the pneumatic test. It is quite obvious that if the various traps of sanitary fittings are ventilated into a special ventilating shaft, that it, in addition to soil-pipe and main-pipe, should also be closed air-tight at its upper extremity during the test. Where a tenement of houses is being examined, attention must be paid to trap-ventilation with reference to siphoning of traps on a soil-stack, or main waste-water stack.

It may be necessary to conduct an inquiry into the condition of a house with reference to ground-damp and dampness in walls. Ground-damp and wall-dampness usually arise from absence or inefficiency of damp-proof courses in walls and from the absence of an impervious layer, such as asphalt, between flooring and ground-level. In such cases removal of planks of flooring at different points of the apartment will reveal the true state of affairs, and digging down to the foundation of the wall of the building on the outside, the existence or absence of a damp-proof course. Examination of the flooring and joists at the points where the planks are uplifted, will show the presence or absence of dry-rot, which is a fungus named *Merulius lacrymans* which quickly grows in darkness, although it only fruits in the light. It quickly spreads along the timbers, permeating the wood in such a manner that planks sometimes can be broken by the hands. A plank so affected looks warped, is dry and cracked, and may or may not exhibit fungus on its exterior. While dry-rot is commonly an indication of deficient under-floor ventilation, it is also due—and this is probably the most common reason in new houses—to the use of imperfectly seasoned wood. We have seen the whole woodwork of an apartment ruined by this fungus within a year after its construction, due to this cause. In the examination of country-houses all the above points must be attended to, and, in addition, the mode of sewage-disposal.

CHAPTER VIII

SEWAGE-DISPOSAL AND METHODS OF SEWAGE-PURIFICATION

By the term *sewage-disposal* is understood any method by which the sewage of a community is conveyed from its vicinity directly or indirectly into a convenient water-way, such as a river, canal, or the sea, without any reference whatever to its purification other than what the processes of Nature may effect; and by the term *sewage-purification*, the removal from the sewage in a more or less efficient manner of those impurities which have been contributed to otherwise more or less clean water, and the restoration to a water-way of an effluent which consists more or less of clean water. In the earlier histories of populous places the former was the prevailing method where a water-way was convenient into which the sewage might be poured, without any reference to its effects, immediate or remote, upon the population which produced it, or upon the riparian populations further down the banks of the stream, and also, without any reference to the amenity of the stream itself. From this practice has arisen the gross pollution of our rivers. Certain populous places on the seaboard confine themselves solely to the problem of sewage-disposal. Where a place is so situated that within a few miles there is a suitable stretch of coastline upon which tidal currents produce a seaward movement, sewage may be conveyed thither, and by storage during flood, may be discharged at ebb tide, with the minimum of nuisance or harm. But such places are comparatively rare. The existence of a convenient water-way, as a river especially, must be held accountable for the gradually-developed practice of sending sewage and rainfall combined in one set of channels, from which the practicability of carrying out efficient schemes of purification has been enormously handicapped. Such a result must be attributed to the accident of circumstances rather than to set design. When the need for sewage-purification became clamant, engineers and sanitarians together divided themselves into two large classes, the dividing line of which was, whether or not, on the installation of purification-schemes, the existing conditions were to remain or to be changed; whether, in short, the rainfall should be sent to the river by one set of channels, and the sewage to the place of purification by a second and separate set of channels, or whether all water—pure and impure—should be sent into the sewers, and by these conveyed to the place of purification. Thus arose the *separate* and *combined* systems as they came to be called. If the question had to be decided with respect to the installation of a sewage-disposal and purification system *ab initio* for a new developing populous centre, as between the adoption of one system or the other, consensus of opinion would, unquestionably, be in favour of the separate system, since, instead of requiring to construct outfall-sewers to take in storm-water, with all the concomitant requirements of storm-valves and bye-passes, and to make provision for the treatment of the excess of storm-water up to six times the dry-weather flow, as the combined system demands, the engineer can construct channels of such appropriate size and shape as are necessary to deal with a fairly constant flow, and at much less initial cost. Further, purification in the combined system, by reason of the variability in amount of storm-water, is inconstant and uneven, and at times illusory, whereas in the separate system there is a comparatively constant and even flow of sewage to deal with, the purification of which could therefore be more complete. But where a huge combined sewage-system has been gradually evolved, the enormous cost requisite for conversion of the combined system into a separate system is a total bar to the introduction of the separate system. The sewage of a populous place is constituted of the products from three distinct sources—viz. :

1. Domestic Sewage, consisting of excretal matters and waste-water, which is composed chiefly of nitrogenous and carbon compounds ;
2. Manufacturers' Discharges, comprehending the waste fluids from divers trade processes, which is made up of the most varied chemical compounds ; and
3. Municipal Sewage, in which may be included waste-water and other fluids from stables, cow-byres, cleansing of streets, courtyards, and public conveniences.

The respective amounts of these in different sewages vary, but on the whole there is general similarity in the composition of those of populous places. It is especially with respect to smaller towns which are identified with certain particular industries, and in which, therefore, the ratios between domestic sewage and trade effluents are abnormal, that the question of composition of sewage has significance with reference to special modes of purification ; for example, where the discharges of pot ale from breweries equal in amount or form a large proportion of the domestic sewage.

Modes of Sewage-Purification may be divided into two classes—viz. :

I. Natural.
II. Artificial.

Under the former may be included *Surface* or *Broad Irrigation*, which under special supervised conditions has been termed *Sewage Farming*. Under the latter are comprehended : (*a*) *Precipitation* or *the Chemical Method* ; (*b*) *Intermittent Downward Filtration* ; (*c*) *Bacteriolysis*, or the *Biological* or *Bacteriological Method*.

Such a classification as above is merely a working one, and does not pretend to be scientific, since in none of the so-called Natural methods is there absent some measure of artifice, while in most of the Artificial methods natural processes and agencies are important factors.

There are two tests by which the efficiency of any method of purification may be tried : (1) its intrinsic worth when in operation under the most favourable conditions ; (2) its applicability to the circumstances of any given place.

I. *Surface or Broad Irrigation.*—In this method, the sewage is conveyed to a convenient sloping piece of land, upon the surface of which, by means of channels in which its flow can be diverted where wanted, the sewage is passed. The water which percolates through the soil ultimately finds its way into natural water-ways, just as does the rain. If the soil be sandy or gravelly, percolation is rapid, provided the surface does not become clogged by too long continuous flow over the same area. The land, so enriched, is used for the abundant growth of certain crops, as Italian rye-grass, etc. Clayey or dense soils are unfitted for the purpose. The method is in operation in many small towns. When viewed from all points, the system cannot be deemed successful or efficient. It is apt to fail in times of severe rainfall and frost, and the area of irrigation is liable in warm weather to become objectionably odorous. Reasonable success, however, may be achieved by close supervision. From the point of view of applicability, it can but best serve small rural towns, and is rarely applicable to large populous centres because of the enormous tract of land required. In Birmingham, for example, where this system is in operation, the sewage-farm of 1240 acres originally in use has had to be increased in area to 2432 acres, or nearly double its initial size. In Berlin, 20,000 acres of land were purchased for this purpose. The results of the system as carried out in the latter city, from the point of view of profit and loss, cannot be compared with those of other places, because the labour is provided chiefly by persons condemned for minor misdemeanours, and therefore costs nothing except for the maintenance of those employed. The system, although still in use in Edinburgh, has out-grown its suitability.

Sewage Farms fail in their purpose without the closest supervision. With such supervision, however, and suitable land, they may be worked to a high pitch of efficiency. For example, the sewage of Wrexham, with a population of 12,000, is treated on 150 acres of good land. As the effluent from this farm runs into the river Dee above the in-take of the Chester Water Company, it is imperative that the effluent should be satisfactory.

II. *Intermittent Downward Filtration.*—The essential factors of this system are: (1) land suitable in kind and in area; (2) preparation of land into a series of plots in the form of large filter-beds; (3) a convenient water-way into which to run the effluent. The intrinsic merits of the system are high. The prime cost of installation is very considerable. Not only must the outfall-sewers be extended to the site chosen, and tanks and channels be erected there, but the site itself must be specially prepared for operation. The land must be excavated to a depth of six feet, the bottom laid with agricultural tile-pipes at regular intervals, and on top of these from below upwards, successive layers of small boulders, gravel, and the natural soil if porous, or, if not, imported sandy soil. These plots, so prepared, are simply huge filter-beds, through which free percolation of fluids not only takes place, but by the action of nitroso- and nitro-bacteria, complex albuminous substances are split up into elementary gases, and nitrites and nitrates are formed. From a tank at the works the sewage during dry-weather flow can be run by gravitation to the plots in series, or where the levels do not allow of this, and during storm-flow, auxiliary pumping from a storage-tank must be employed. The sewage is distributed by channels to a given plot or plots working in series, and in such rotation that each plot or series works for six and rests for eighteen hours, so as to allow of complete re-aeration of the soil. The percolated fluid which constitutes the effluent finds its way by an artificially prepared channel into an adjacent water-way; the solids are incorporated into the soil by ordinary agricultural operations, and thus a soil is made rich for the growth of crops, such as hay, cabbages, turnips, osiers, etc. The applicability of this method is affected by three main factors: (1) its relatively high prime cost; (2) the extent of land needed for a large population; (3) the difficulty of procuring convenient and suitable land. The filtering-area of ground required under the best conditions is 1 acre per 1000 of population, and under less favourable, 1 acre per 150 to 500 of population. The extent of land necessary, therefore, for huge populations, coupled with the high prime cost of its preparation and the cost of maintenance, tends to make the scheme inapplicable for other than small town populations. At the same time the cost of working and maintenance is much less than that of other schemes, and when properly managed, the land can be made to yield some return in the crops produced.

III. *Precipitation Methods* or *Chemical Treatment.*—Of the very many substances which have been proposed as chemical precipitants of the organic and inorganic matters in sewage, few have survived the tests of time, cost, and efficiency. Those which have survived these crucial tests are: (*a*) Lime, (*b*) Alumina, (*c*) Magnesia, and (*d*) Iron; used not singly but in some form of combination. Lime is the oldest precipitant in point of time of use, but unless it is used in sufficient quantity, it fails to precipitate effectually organic matters. When used in such quantities it produces two objectionable results, viz.: (1) an alkaline effluent which becomes subject to secondary decomposition, causing the effluent to be richer in putrescible matter than the original sewage, and hence causing the stream into which the effluent is passed to become a definite nuisance; and (2) a bulky decomposable sludge. The treatment by lime was then united with filtration of the effluent; but this also proved inefficient, since the finely-divided, putrescible, slimy material in the effluent rapidly clogged the filters. By reason, therefore, of its needed use in comparatively large amounts, its alkaline, putrescible effluent, and the bulk of sludge produced, the use of caustic lime solely, or combined with filtration, came to an end. Next followed the conjoined use of coarse sulphate of alumina with lime. This produced two marked results—viz. reduction in the amount of lime needed, and a more perfect and more rapid sedimentation of solids. To these might be added a third: a more neutral condition of effluent, and hence less liability to secondary decomposition. The chemical action of alumina on sewage is somewhat akin to that of iron, inasmuch as it tends to split up complex and stable albuminoid bodies into less stable and complex nitrogenous compounds in the direction towards the formation of ammonia, but unlike iron, it does not possess the property of oxidising carbonaceous compounds. When alumina and lime are used together, the sulphuric acid of the former unites with the lime and leaves the alumina in the form of hydrate, $Al_2(OH)_6$, which, being a gelatinous, viscid substance, more readily carries down mechanically particulate matters in suspension.

The property which alumina has of fixing nitrogenous matter by entering into some form of loose combination with it, would appear to be analogous to the action of a mordant in dyeing processes. Relatively to iron, alumina has less power of fixing phosphoric acid and ammonia, and like lime it contributes of itself no manurial value to the sludge. The combined use of these precipitants with filtration of effluent has been demonstrated at Coventry, Glasgow, and other places to produce a good effluent; but both are essential to achieve this. At the Dalmuir sewage-works, Glasgow, lime and iron (ferric) sulphate are used as precipitants.

As an offshoot of the Lime-alumina process is the *A.B.C.* process, which has been in operation in Aylesbury, New Kingston, and other places for several years. The precipitants are alumino-ferric, blood, clay and charcoal—hence the name of the process from the initial letters of these substances. The mode of treatment is as follows: On entering the works, the sewage is screened, measured, and mixed with regulated proportions of the three last-named chemicals, and then, later, with the alumino-ferric. Thus mixed, the sewage is passed into four precipitating tanks, in which rapid sedimentation of solids takes place. Out of the fourth tank of the series flows the effluent which is passed into the water-way. The precipitated sludge is then pumped to a sludge-well, whence it is forced into filter presses. The cake so formed is thereafter dried in a Borwick's drying cylinder, the fumes therefrom being condensed by a scrubber. The product is sold as "native" guano. It is claimed for this process that not only is the sewage efficiently purified, which is the prime object, but also that the sludge forms a comparatively valuable, innocuous, transportable, and inodorous manure. Whatever manurial importance this product possesses, however, must be held to be due to the added ingredients, and not to those native to it. The Sewage Commissioners in their Fifth Report (1909) say that the process as carried out at Kingston is a very efficient form of precipitation. Another precipitant of importance, in one form or another, is iron. So far back as 1846 and 1858 patents were taken out for the use of iron in the treatment of sewage; that of 1858, by Thomas Spencer, a London analytical chemist, was for "Improvements in the treatment of iron ores and ferruginous sands, and certain applications arising therefrom, No. 1415." When iron is mixed with sewage one of the most noteworthy changes which takes place, detectable in the effluent, is the substantial increase in the amount of free ammonia and decrease of albuminoid ammonia as compared with those respectively in raw sewage. The action of ferric chloride upon carbonaceous and nitrogenous bodies in sewage is to liberate carbon from the former to be oxidised into CO_2, and nitrogen from the latter, which uniting with free hydrogen, forms NH_3; in this way accounting for the increase of free ammonia found. It would appear that the water bound up in the hydrated oxide of iron does not exist as true water—which is very stable—but as *hydroxyl* which is very unstable, and that iron salts therefore play a part analogous to the action of permanganate of potash in the Wanklyn process for conversion of albuminoid bodies into ammonia. The action of liberating the carbon may be represented by the following equation—

$$3Fe_2(OH)_6 + 3C = 6Fe(OH)_2 + 3CO_2 + 3H_2.$$

in which the hydrated ferric oxide becomes reduced to the ferrous condition in oxidising the carbon, the carbon to be oxidised to CO_2, and nascent hydrogen to be set free. The hydrogen then unites with the freed nitrogen to form NH_3; thus—

$$6Fe(OH)_2+3H_2+N_2+3H_2O+3O=3Fe_2(OH)_6+2NH_3\ ;$$

in the meanwhile, the ferrous oxide takes up fresh oxygen from the air and reverts to the ferric state.

When iron is used as a precipitant, efficient filtration is imperative to permit of re-oxidation of the ferrous oxide.

Iron may be added to sewage in a variety of forms, as for example :—

1. A solution of Ferric Chloride ;
2. A solution of Sulphate of Iron ; as in the *International*, *Polarite*, or *Ferrozone* process ;
3. A solution of Iron-Alum ;
4. A combination of Ferric Chloride and Lime ; as in the Barry Process ;
5. The electrical process, in which iron is set free by the electrolysis of water.

The first is used as any other precipitating agent, and needs no further explanation. The second consists in adding to the crude sewage a solution of ferrous sulphate of regulated strength, popularly called "ferrozone," and in filtering the effluent through beds composed of oxide of iron—called Polarite by some and Magnetite by others—a ferroso-ferric oxide, or magnetic oxide of iron. The third consists in adding a solution of crude iron-alum, as is done at Southampton. The Barry process uses both ferric chloride and lime, the latter assisting in the more perfect sedimentation of the iron as ferrous hydrate, and thus less work is thrown upon the filter-beds. The sewage is first mixed with the iron, and thereafter with the caustic lime. Adequate filtration is absolutely needful in this process, since the utility of the iron for repeated use is only conserved when the iron is oxidised back to the ferric state, and this is achieved by re-aeration of the filter-beds during their intervals of rest.

Webster's electrolytic process is one in which iron is shed by the action of electricity into the passing current of sewage in the following manner. The sewage is passed at a low velocity through a chamber which is broken up into part sections by the projection into its interior of iron plates forming flanges. These iron flanges are in the electric circuit, and when the current is in action through the apparatus, one set becomes the negative, and the other, the positive poles. From the latter only, hydrated ferrous oxide is produced by the action of the oxygen liberated from electrolysis of the water by the electric current upon the iron plates. This ferrous oxide is oxidised by the dissolved oxygen in the sewage into ferric oxide which oxidises the organic matter, by which it is converted back into the ferrous state ; and so by alternate oxidation and deoxidation, the iron continues to act upon the organic constituents of the sewage. The sewage, mixed with the iron in suspension, then passes from the electrolysing chamber into settling-tanks, and thereafter the effluent is passed through ordinary sand filter-beds.[1]

[1] *Vide* a paper on "Some Sewage Experiments," by Corbett, *Jour. San. Instit.*, vol. xxiii., part iv., p. 661 *et seq.*

A modified method of purifying sewage electrolytically is that known as the Oxychloride System. This consists in the electrical decomposition of sea-water and is in use at Guildford.[1] There is another modification of the alum-iron process worthy of description. It is the process carried out at Heaton Mersey for purifying the sewage of the Heaton Norris Local Board District. The points of interest in it are these: (1) It is a constant-flow system; (2) The precipitant in use is alum cake which is added prior to the sewage passing by gravitation into the precipitation-tanks; (3) After precipitation, the effluent flows over a sill forming a cascade about one foot in height, on its way to the filter-beds, thus promoting aeration of the oxidisable constituents in the effluent; (4) The filter-beds are three in number, and the composition of each is different. No. I. has an area of 60 sq. yards; and the filter-strata, from above downwards, are made up of sand, coarse and fine gravel, of one inch and six inches thickness respectively, both of which strata rest on tiles which are perforated with five openings to the inch. Aeration of the filter when not working is effected by pipes. This filter, therefore, acts only as a mechanical coarse strainer. No. II. filter-bed is made up of a layer of magnetite and sand mixed, of 2½ inches depth, resting upon gravel. It has an area of 35 sq. yards. No. III. is constituted from above downwards of the following layers, viz.: sand 1 inch, magnetite 7 inches, and pebbles and tiles as above. It has the same area as No. II. The effluent after its passage through these has a bright, clear appearance, contains no matter in suspension, and possesses no smell. It is claimed for the process that it combines rapidity of filtration and a decreased filter-area, with the production of a pure, innocuous effluent, at half the cost of any filtration-system in operation. In these works, the sewage, which contains no trade-effluents, is that of 6000 persons, and amounts to 240,000 gallons per 24 hours. Of iron, generally, in sewage-treatment, it may be said that it produces more marked fixation of the phosphates than either lime or alumina singly, or in combination.

The only other precipitant which has borne the tests before named is Magnesium chloride. This is the main constituent of the chemical salts used in Hillé's process, which is in operation at Windsor, Tottenham, and other places. This process is a modification of the lime process, because lime and a proportion of tar are also added. The effluent is subjected to what filtration irrigation can give. Another modification of the alumina process is that of the Oxygen Sewage Purification Company, in which, however, Manganate of Soda and Nitrate of Soda are additionally used. This process may be summed up as follows: (1) Suspended matters in the crude sewage are first separated by simple subsidence; (2) Manganate of Soda is added, to oxidise organic matter, that salt giving up oxygen, and becoming reduced to the insoluble peroxide of manganese, which in its subsidence carries down mechanically the particulate sewage, the manganese being afterwards recovered; (3) Sulphate or Chloride of Alumina, preferably the latter, is next added, which throws down the floating, flocculent matter left from the former stage; (4) To the clear resulting effluent small quantities of Nitrate of Soda, to aid nitrification, are added; (5) Thereafter, the effluent is turned into the nearest stream. In this process there are three sediments: (1) the crude solids deposited by gravity ; (2) the deposit from use of Manganate of Soda ; (3) the deposit from the alum salt ; thus mechanical subsidence, chemical precipitation, and oxidation all share in the production of the result.

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[1] *County and Municip. Record*, 6th Dec. 1904, p. 141 *et seq.*

Another method of purification is that known as the Amines process. The process consists of adding definite quantities of milk of lime and herring brine, from which combination is evolved, according to the inventor, a gaseous reagent called *aminol* which is soluble in water. The sludge which results after precipitation is said to contain 90 per cent. of water. The inventor claims that the effluent is not only clear but is sterile.[1]

The outstanding objections to all precipitation-methods are the formation of sludge, and the need for its removal. Burghardt's analysis of the fresh sewage-sludge from the lime process is as follows :—

Mineral matter	6·22 per cent.
Loss on ignition of dry sludge (organic matter)	2·50 ,,
Water	91·28 ,,
	100·00 ,,

Composition of the above mineral matter in parts per cent. is as follows :—

Silica and insoluble matter	10·418
Ferric oxide and alumina	9·511
Iron sulphide	0·115
Calcium carbonate	64·526
,, sulphate	3·621
Magnesium carbonate	11·613
	99·804

Our analyses of the sludge at the Glasgow works after having been filter-pressed, show the following to be the composition of an average sample :—

Total solid residue		41·50
Mineral matter	= 24·38	
Organic matter (by ignition)	= 17·12	
	41·50	
Water		58·50
		100·00
Total nitrogen (estimated by Kjeldahl's method)		= 0·788
Total nitrogen in terms of ammonia		0·960

By reason of the comparatively low manurial value of the fore-going and the difficulty experienced in its disposal, the authorities at Glasgow concluded to dry the compressed cake artificially, thereby getting rid of about 90 per cent. of water. The following analyses of this compressed and steam-dried cake, ground into powder, show its composition in parts per cent. :—

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[1] *Lancet*, vol. ii., 1889, p. 601.

		Davidson.		Glaister.
Total solids		89·37		93·00
Mineral matter	49·70		66·5	
Organic ,,	39·67		26·5	
Water		10·63		7·00
		100·000		100·000
Nitrogen		1·73		1·90
,, in terms of ammonia		2·10		2·30

It will be apparent from the foregoing analyses, therefore, that the sludge from precipitation-processes, even when compressed and dried, forms a manure of comparatively low value only. Further, the low figures for phosphoric acid indicate that the bulk of this valuable manurial element has disappeared with the effluent into the river. If the sludge could be disposed of for agricultural operations, precipitation processes would become more workable and less costly.

The following Table will show the amounts of sludge produced by different methods of treatment.

TABLE XXXIV

Results *per annum*, in tons of wet, pressed, and dried sludge, of Treated and Non-treated Sewage, per 10,000,000 gallons of *daily* average sewage by various Precipitants.

Character of Sewage	Tons of Wet Sludge	Tons of Pressed Sludge	Tons of Dried Sludge
Raw Sewage (untreated)	58,000	11,680	5,840
Lime, only	114,200	22,840	11,420
Ferric Chloride, only	120,000	24,000	12,000
Iron and Alumina	120,000	24,000	12,000
Polarite Method	75,000	15,000	7,500
Electrical Method	69,000	13,800	6,900

The foregoing figures are founded on the results obtained in the Salford experiments of 1890 by the Messrs Newton, and they are intended to show the amount of sludge which is formed from 3,650,000,000 gallons of sewage, after different precipitants had been used. At the Glasgow works during the year 1897–1898, the number of gallons treated was, in round numbers, 3,740,000,000, a figure sufficiently near the former for comparison. The quantity of wet sludge taken from that quantity of Glasgow sewage was 180,000 tons, or, in round figures, one ton of sludge per 200,000 gallons of fresh sewage; and of pressed sludge, 17,000 tons, or one ton of pressed sludge cake per 10 tons of fresh sludge. From these figures, it will be seen that the amounts obtained in the latter are higher than the highest figure of the Salford experiments.

In the Act of Parliament obtained by Glasgow for extending this mode of purification to the whole sewage of the city, powers have been given to the Corporation to transport the sludge out to sea, and to deposit it therein. When the completed scheme is in operation, since the estimated amount of sewage to be treated will not be less than five times more than now treated at Dalmarnock (based on the figures given of the results of the partial scheme), it appears that annually the city will have to deal with between 950,000 and 1,000,000 tons of crude or wet sludge, and to dispose of, in one way or another, between 90,000 and 100,000 tons of pressed sludge-cake as the result of operating upon about 20 billion gallons of sewage.

In all schemes of precipitation, filtration is a necessary adjunct before the effluent can be passed without nuisance into a water-way. While, therefore, precipitation-processes are applicable to large populous centres, and are capable when worked properly of effecting a high degree of purification, they are very costly not only in installation but also in maintenance and working,

IV. *Bacteriolysis*, or *the Biological* or *Bacteriological Treatment.*—From time to time during the last half century, since drains for the transportation of sewage came into more general use, when these or cesspools, which for long periods had been so used, were opened, and were expected to contain quantities of highly offensive material, surprise was expressed on finding them comparatively empty and entirely free from objectionable, offensive odours. But the reasons therefor were passed over without further inquiry, doubtless due to the fact that the effects of micro-organisms in the destructive metamorphoses of organic matter were not even dreamt of, much less understood or investigated.

The first publication which indicated the probable action of micro-organisms as the natural cause of purification of sewage, was a pamphlet entitled " A New, Hermetically Closed, Completely Inodorous, Incessantly Self-Emptying Cesspool, invented by M. Louis Mouras, propriétaire, Vesoul (Haute-Saône)." This pamphlet was written by a parish priest named Abbé Moigno, and was published in French about the year 1883. The substance of its facts is the following : In 1881, M. Mouras asked the Abbé to publish his observations of a cesspool-system which the former had had in operation for about twenty years previously. The features of the cesspool are fully named in the title of the pamphlet. It was closed from the air ; its products were inodorous ; and they were found valuable as a liquid dressing for cultivated land. According to the Abbé, " by a mysterious action which reveals an entirely new principle, the cesspool transforms all that it receives, both solid and liquid evacuations, in a tolerably short time, and without any addition of chemical ingredients, into a homogeneous and scarcely turbid liquid, which holds everything in suspension, in a state of filaments almost invisible, without leaving any deposit against the sides of the soil-pipe, or at the bottom of the drain-pipe." Not satisfied only with noting these results, the Abbé discusses the rationale of the causal factors in the process. He hints that the cause may be ammonium sulphide, but he adds this significant remark : " May it not be discovered that the mysterious agents of this fermentation, cause of the decomposition and liquefaction of the fæces, are the vibrios, or rather the anaerobes of M. Pasteur, which the oxygen kills, and which only employ their devouring activity when excluded from the air ? " He set about experimenting on the subject, and had a tank of glass made, so that he might study the whole process of metamorphosis. He then describes the changes which he saw the sewage undergo toward complete disintegration. He thought it likely that gases would be generated by the processes of fermentative decomposition, and to test this, he caused a tap to be fixed in the top of the tank, over which he placed a bladder securely fastened. He found, however, that no distension of the bladder occurred, indicating that in the absence of air there was no free disengagement of gases, and that they were held in solution, but if air was admitted into the tank the gases were liberated and the bladder became distended. He thereupon concluded that, for the more efficient operation of the process, air should be rigidly excluded from the tank. He further believed that by the process any pathogenic organisms which might be present in the sewage would be destroyed. The process was patented in France in 1881. The next account, in point of priority, comes from Barcelona.[1] The British Consul in Barcelona wrote a letter in 1893, in which he narrated the operation of the above system on the property of a merchant in that place in the drainage of his factory and private residence. The Consul states that he had personally inspected the process and its results after five years' working. He found the effluent colourless and odourless, and that it could be removed for manurial purposes without the least nuisance. The next attempt to prove the efficacy of bacterial action in purifying sewage was that of Dibdin, who, between 1892–1896, carried out a series of experimental investigations in open beds, under the auspices of the London County Council, on the biological treatment of sewage.

By Cameron of Exeter, in 1895–1896, an experimental installation was laid down in that city to deal with the sewage of the parish of St Leonard. The principles which Cameron adopted were practically those laid down by Abbé Moigno, but Cameron called his tank the "Septic tank," in place of the long name given to it by Moigno. Since, however, the effluent of the septic tank at Exeter was not employed in the irrigation of land, but was to be discharged into a stream, he passed it through beds, which, while they exercise filtering action, also develop microbic action, from which the names "filter-beds," "bacteria-beds," and "contact-beds" have been given to them.

Rationale of the System.—The bacterial treatment of sewage has now been practically resolved into one of three methods, viz. :—

1. Where the crude sewage is run upon filter- or contact- or cultivation-beds, composed of coke or other materials, the rate of flow of sewage being regulated, and the contact-beds themselves subjected to alternate periods of active work and complete rest;

2. Where the crude sewage is first run into a grit-chamber, then into a closed, dark tank, called the septic tank, and, thereafter, is passed on to contact-beds—all the time in a slow but continuous flow—in which it is allowed to remain in contact for $1\frac{1}{2}$ to 3 hours, after which the effluent is passed into a neighbouring water-way;

3. Where the sewage is passed into an open settling-tank, thence to the contact-beds, and in turn to the stream.

The first may be fitly termed the *aerobic* method; the second, the combined *anaerobic* and *aerobic* method; and the third, the same as the second; for although there may be apparent differences in the engineering technique in the third compared with the second, the ultimate action is essentially identical. These apparent differences may now be described. In the open settling-tank of the third method, a thick, frothy, tough scum gradually forms upon the surface of the contained sewage, provided that the rate of flow is properly regulated, which scum, to all practical intents and purposes, plays the part of the roof of the septic tank, inasmuch as it prevents the entrance of light, and to some extent of air to the sewage column underneath, and so the action of anaerobic organisms is allowed to proceed. The integrity of the scum-covering is liable upon occasion to be disturbed and broken up by the action of high wind, but only, however, for short periods. When this mode is adopted, the tank ought to be sheltered by a protecting wall.

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[1] Boyce, *Brit. Med. Jour.*, 1898, vol. ii., p. 273.

Nothing has been better proved in the whole range of bacteriological work than the power of organisms to split up complex organic bodies into simpler constituents, as nitrogen, sulphur, carbon, hydrogen, and others, and that different groups of organisms are synthetic in their action in respect that they are able to oxidise nitrogen from the lowest to the highest state. In the metamorphosis of the complex fluid—sewage—each group of organisms has a definite part to play. The anaerobic forms are chiefly concerned with the resolvent or analytic decomposition of contained substances, and the elements liberated unite with one another to form definite gases or other compounds which are retained in solution ; thus sulphur unites with hydrogen, or with that gas and nitrogen in addition, to form H_2S and NH_4HS respectively, while nitrogen unites with hydrogen to form NH_3, which, in turn, may unite with acids, as H_2SO_4, HCl, or CO_2 to form the sulphate, chloride, or carbonate respectively. The foregoing action is accomplished in the dark, airless tank. When, however, the sewage so acted upon passes in its slow moving course out of the tank and over the artificial weir, it becomes partly re-oxygenated by the air, and absorbs in addition the other atmospheric gases, nitrogen and carbonic acid ; and thus freshly aerated, it is passed on to the surface of the contact-beds. In these contact-beds, the anaerobic organisms continue their operations during the time the beds are full, and the aerobic organisms take up the work while the beds are empty and resting. Two kinds of action take place in these beds—viz. (*a*) the mechanical one of straining or filtration ; (*b*) the biological, or bacteriological. The former depends upon the coarseness or fineness of the constituents of the contact-bed, but it is not the most important office of the bed. The period in the life of a contact-bed at which it does the most efficient work is not when it has been newly laid, but after it has been in operation at intermittent intervals for at least two or three weeks ; in short, so soon as the aerobic organisms have had time to adequately grow and multiply. Hence the work of the contact-bed is not so much that of filtering the effluent, as of assisting microbic action.

The work of the aerobic organisms is mainly synthetic or constructive. They are chiefly, for sewage purposes, divisible into two groups—viz. :

1. The Nitroso-bacteria ; and
2. The Nitro-bacteria ;

each of which exercises a limited, but definite action upon the above-named products. The former group attacks the ammonia and its compounds, and oxidises the nitrogen liberated into the form of nitrous acid, which forms with constituent bases of the sewage—potash, soda, etc.—nitrites of these bodies. Nitrous Acid (HNO_2), however, is a comparatively unstable compound. The nitro-bacteria then build up further the oxidation-process by causing the nitrous acid to unite with another atom of oxygen, thus forming *nitric* acid (HNO_3), the highest and most stable form of oxidised nitrogen. The range of the action of nitrification is only limited by the amount of calcium present in the contact-bed, or in the soil. These actions and results have been abundantly proved by the researches of Warington, Lawes and Gilbert, Frankland and many others. The nitric acid unites with the bases, potash, soda and ammonia, to form nitrates, immense beds of which are found in nature in South America and other parts of the world, and which form important constituents of artificial manures. As the combined effect, therefore, of filtration and bacterial action, the effluent passes from the contact-beds, as a clear, inodorous, and practically tasteless fluid.

The Aerobic Process.—In this process there is no closed septic tank as such. The sewage, after having been screened of any coarse excreta, is run intermittently over open filter- or contact-beds until the sewage is on a level with the top layer of the filter-bed. It is allowed to remain in contact with the material of the bed for two or three hours—that is, 1½ hours in filling, and the same time standing full—and is, thereafter, allowed to drain through. The bed, after being emptied, is allowed to rest for eight hours to permit of re-aeration, when it is again filled and the process repeated. Experience has shown that a period of four weeks is necessary before such a bed attains its fullest purifying power; in other words, the maximum growth of nitrifying organisms is then reached. In certain installations, however, the effluent from the primary or coarse contact-bed is caused to pass through a secondary or fine contact-bed. The effect is to produce a much purer and clearer effluent. The work which falls upon it to perform is that of oxidising the dissolved matter in the fluid, the suspended matter being mainly arrested in the coarse contact-bed.

In the Anaerobic-Aerobic, or Septic Tank Process, the sewage passes through a grit-chamber, where heavy mineral detritus subsides, then through the septic tank, then over the artificial weir for re-aeration of the fluid, and thence on to the contact-beds, from which by the effluent channel it passes into a water-way. There is no screening of coarse excreta from the sewage in this process as there is in the other, consequently more work falls to be done by the anaerobic organisms. In order to produce the automatic distribution of the sewage after it has passed through the septic tank and has been re-aerated, various ingenious arrangements have been devised. In Cameron's process automatic alternating gear is an essential feature, in which the various stages of filling, resting full, discharge, and aeration are produced by means of an overflow from the filter last filled. In Adam's process, it consists in emptying the tank down to a certain level by siphon action.

While microbic action is the chief factor in the bacteriological process, it must, however, be borne in mind that in the processes of irrigation, intermittent downward filtration, or indeed in any method in which the sewage or its effluent is applied to land or filter-beds, it plays a not unimportant part. Neither is the action awanting in the precipitation-process; but in it the action is probably more anaerobic in character than aerobic, not only in the sewage itself, but particularly in the alkaline sludge.

In connection with the bacterial treatment, it has been asked, is it applicable to all kinds of sewage? Microbes do not live and multiply so freely in acid media as in alkaline. There are several trade effluents which are highly acid in reaction, and therefore, where these bulk largely in the sewage of a particular place, the applicability of the bacterial system becomes an important question. The answer must be based upon the relative proportion of trade effluents to ordinary domestic sewage. In most cases the latter is sufficiently in excess to neutralise

TABLE XXXV

Analyses of Samples of Sewage from Yeovil in parts per 100,000

Number	Date and Time	Total Solids	Oxygen consumed	Chlorine	Nitrogen			
					Free or Saline	Albu-minoid	Nitrite	Nitrate
		SERIES I						
Raw Sewage	Nov. 14, 1899, 8 A.M.–NOON	134	11·22	11·8	4·85	1·64	Nil	Nil
Tank 4	Nov. 15, 1899, 8 A.M.	90	5·2	10·0	3·45	0·57	Nil	Nil
Filter 5	,, ,, 1.15 P.M., No. 2 Filter	78·5	2·22	10·0	1·64	0·29	0·044	0·412
,, 6	,, ,, 2.45 P.M., No. 7 ,,	80·5	1·72	10·2	1·23	0·21	0·015	0·60
,, 7	,, ,, ,, No. 8 ,,	80·7	1·48	9·8	0·99	0·16	0·030	0·712
Average Filter		79·7	1·81	10·0	1·29	0·22	0·030	0·575
		SERIES II						
Raw Sewage	Nov. 14, 1899, 4–8 P.M.	147	8·8	22·0	3·0	1·03	Trace	Nil
Tank 9	Nov. 15, 1899, 4–8 P.M.	123·5	7·04	17·3	4·08	0·82	Nil	Nil
Filter 10	,, ,, 9.25 P.M., No. 2 Filter	87·5	2·22	14·4	1·64	0·32	0·12	0·12
,, 11	,, ,, 10.55 P.M., No. 7 ,,	90·0	2·64	13·3	1·22	0·30	0·037	0·188
,, 12	,, ,, ,, No. 8 ,,	88·0	0·53	12·6	0·82	0·19	0·024	0·576
Average Filter		88·5	1·80	13·4	1·23	0·27	0·060	0·295
		SERIES III						
Raw Sewage	Nov. 15, 1899, Midnight–4 A.M.	59·0	2·1	4·8	1·22	0·30	0·018	Nil
Tank 13	Nov. 15, 1899 ,, ,,	124·0	6·08	15·2	4·08	0·72	Nil	Nil
Filter 14	,, ,, 6.30 A.M., No. 3 Filter	85·5	2·55	14·6	2·46	0·26	0·050	0·12
,, 15	,, ,, 8. A.M., No. 7 ,,	90·0	1·81	14·0	1·48	0·21	0·032	0·26
,, 16	,, ,, 8. A.M., No. 8 ,,	87·5	1·07	14·0	1·20	0·20	0·027	0·46
Average Filter		87·7	1·81	14·2	1·71	0·22	0·036	0·28

the acidity of the former, and hence up till now in practice no sewage has been found which is not capable of being purified by the system. Pot-ale or burnt ale, which is the residue from the first distillation of whisky, is probably the most refractory constituent. It contains between 30 and 40 grains of free or saline, and between 40 and 60 grains of albuminoid ammonia per gallon, yet this is overcome by the aerobic bacterial method, as the effluents, which are clear, without colour and odour, and do not undergo secondary decomposition, show infinitesimal amounts of free, and only 0·1 grain of albuminoid ammonia per gallon, while the nitrates are as low as 0·2 grain per gallon. These results, moreover, seem to be obtained whether the pot-ale is treated in its natural acid state, or after the addition of a small proportion of lime. Further, from the experiments at Yeovil, the sewage of which is alleged to be exceptionally foul by reason of the trade effluents from glove-works, dye-works, tanneries, fell-mongering works and breweries, it is demonstrably clear that chemically the process is effective, as the preceding series of analyses by Dr Rideal show (page 283).

Percentage Purification	Organic Nitrogen	Oxygen Consumed
Tank on Raw Sewage	64·81	17·09
Filtrate on Raw Sewage, First Filtrate . .	85·55	68·38
,, ,, Second ,, . .	87·0	79·10

The results of the treatment of Yeovil sewage, estimated chemically, having been considered by the Local Authority to be entirely satisfactory, and to justify the expenditure of a large sum on works large enough to treat the whole of the sewage, such a scheme was embarked upon. But in 1901, examination of the septic tank liquor and septic tank sludge, as well as of samples of coke from the coarse and fine contact-beds having been made bacteriologically by Houston for the Royal Commission on Sewage Disposal,[1] the disconcerting discovery was made of the presence of the anthrax bacillus in them all. From the results obtained in these examinations, Houston concluded that there were "no good grounds for anticipating that the new scheme will remove the danger arising from the presence in the final effluent of living and virulent anthrax spores. That anthrax spores will eventually pass through the septic tanks and bacterial beds can hardly be doubted. The land might possibly effect their mechanical separation if it were of good quality, but this would appear not to be the case."

The origin of this micro-organism and its spores in this sewage is not difficult to find when one considers the effluents from the hide-factories of that town. The total volume of domestic sewage, effluents from breweries and hide-factories, and surface-water is calculated to amount to about 143,000,000 gallons per annum, of which the hide-factories' effluents constitute about one-ninth of that total.

From the point of view of purification, it cannot be doubted that the problem at Yeovil is an interesting and important one.

If the chemical side of bacterial treatment be considered, the fact appears that from the time the sewage enters the septic tank, or open tank, till it appears as effluent, there is a loss in the total nitrogen; in other words, the nitrogen of the effluent falls short of that of the crude sewage. This has been noted by many observers. The results obtained at Sutton, Leeds, Manchester, and elsewhere show this; in these places the percentage of loss was 15, 7 and 39 per cent. respectively. This loss of nitrogen is accounted for in two ways, viz.: (*a*) by the escape of free nitrogen from the sewage by the action of organisms of the anaerobic type, or (*b*) by the utilisation of nitrogenous compounds as foods by small insects and other animals, as worms, etc., in the filter-beds. There is another explanation, however, and that is, that there may be nitrifying and reducing organisms working together, the former building up from ammonia the oxidised nitrogen compounds, and the latter reducing such compounds when formed, for it is quite clear that aerobic organisms are not alone present in the contact-beds.

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[1] *Second Report*, 1902. Cd. 1178, p. 31 *et seq.*

Materials of Contact-Beds or Filters.—The contact-beds are either made by constructing artificial walls, or by simply excavating the ground, where such is of clay; in either case, loose-jointed tile drain-pipes are laid along the bottom, and these lead to the outlet by which the effluent passes. Upon these pipes is placed the filtering or contact material, which may consist of broken clinker, burnt ashes, coke or pan-breeze, the last named being used at Barking. In the first or coarse contact-bed the material is composed of sizes which will pass through a two-inch ring, but not through a half-inch ring. In the second or fine contact-bed, such sizes as will pass through a quarter-inch but will not pass through a one-sixteenth-inch sieve are put down. It has been found experimentally that when the material is so composed, the filter-beds do not become so easily clogged, aeration is most efficient, and the effluents are better. The depth of the beds varies. At Barking the depth is 6 feet, at Sutton 3 feet 6 inches, and at the Crossness experimental installation it is 13 feet. It might be expected that these beds after prolonged use would become malodorous; but such has not been found to be the case. Indeed, but for the slime which forms in the upper few inches of the bed, the whole bed, and lower layers especially, are fresh after years of working. This is the result of re-aeration. In the experimental stages of sewage-treatment by contact-beds, it was thought sufficient that single coarse contact-beds should be installed. But it was found experimentally that such were insufficient, since precipitated solids were apt to be discharged along with the effluent. The only conditions in which such primary beds are found sufficient are where the sewage is applied in drops, by means of mechanical sprinklers, and where the outflow at outlet is slow and continuous. In present-day installations, therefore, both primary and secondary contact-beds are put down, the materials of which are of the composition and size hereinafter described. The effect of such primary and secondary contact is not only to secure more efficient bacterial action, but to produce better effluents. In occasional instances, however, an attempt is made to secure the same effect by one bed only—by the bed being composed of strata of different degrees of size of filtering or contact material. At Barrhead, near Glasgow, for example, the total depth of the beds is four feet, the lower three feet nine inches of which are made up of engine-ashes screened through a $\frac{3}{4}$-inch screen and rejected by a $\frac{1}{4}$-inch screen. The upper three inches are composed of finer material than the lower stratum. But modifications in the composition of these filter-beds have from time to time been proposed. In Stoddart's sewage-filter, which has no built retaining walls, the filtering-material consists of coarse rubble, ballast, coke, or other material, varying in sizes between two and four inches, and laid to a depth of six feet. The whole bed is laid upon a concrete floor, with a fall toward one end. The sewage is applied, not *en masse*, but in a continuous stream of drops, by means of distributors which consist of corrugated iron of alternate ridge and gutter form, the ridges being notched at regular intervals. It is claimed for this system that it is a continuous flow system, that no land treatment of the effluent is required, that the effluent is good, and that the filter-bed has a filtering capacity of 1000 to 2000 gallons per square yard per 24 hours. In the Candy system, the sewage, after having been passed through a grit-chamber, is evenly distributed on aerobic contact-beds by patent "sprinklers." The sprinkler consists of hollow perforated arms springing from a central spindle or stem—like the spokes of a magnified bicycle wheel—set in a basin. The arms may be two or more in number. The sewage is delivered into the basin, and thence flows into the hollow arms or spokes from openings in which it spirts in a series of jets, causing the whole apparatus at the same time to revolve. A head of eight to ten inches of sewage is sufficient to set up the rotatory movement of the spindle and spokes or arms. In the circular movement thus set up, the jets of sewage, freshly oxygenated in falling through the air, are showered evenly on the bed. The Sewage Commissioners in their Fifth Report have investigated the various methods of feeding percolating filters, and their observations respecting these will be found on a succeeding page (p. 297). In order to re-aerate the beds the action of the sprinklers is intermittent, in that they cease acting a few minutes at frequent, periodic intervals, which effect is produced by siphon action. The materials of the percolating beds consist of broken brick and other like substances. The system is, practically, a continuous one.

The Ducat Filter-bed.—The principle of the bed is to produce oxidation of the sewage by causing it to drip upon the filter-bed in drops, the sewage being distributed from the top of the filter-bed by means of patent automatic tipping-troughs. No preliminary treatment of the crude sewage is employed. The effect of the free movement of air in and through the filter enables the aerobic organisms to freely attack and purify the sewage. The filtering-material consists of stone chips, cinders, pebbles, gravel, or other like material. The effluent is clear, colourless, and odourless. The bed is capable of acting perfectly upon 250 gallons of sewage per square yard per 24 hours. The results of its operation at Hendon are admirable, and it is comparatively inexpensive to instal. It ought to be termed a bacterial filter.

Scott-Moncrieff Process.—This is also a continuous process, and is in operation at Caterham Barracks, where it deals with the purification of about 16,000 gallons of sewage daily. The features of the process are these: the sewage is passed into one end of a tank, called by the inventor a "cultivation-tank." The liquid portion of the sewage passes upwards through a perforated grating, which forms, as it were, a false bottom of the tank, and which arrests the larger solids. It then passes through a layer of flints laid on top of the perforated grating, filling the tank until it rises to the level of the outlet, which is placed about 2 inches higher than the level of the entering sewer. It is then passed through a series of wooden trays each containing a layer of coke in pieces about the size of horse-beans, and thence to an irrigating plot. The sewage thus undergoes subsidence, screening, coarse filtration and fine contact during the course of the continuous flow. The effluent is clear, colourless, odourless, and non-putrescible. There is a minimum amount of sludge formed. From analyses of the effluents, it has been shown that there is considerable reduction in free and albuminoid ammonia and in oxygen consumed, and that nitrification takes place quickly in the wooden coke-trays. The sewage from the cultivation-tank contains about 35 parts of ammonia per 100,000, and the effluent from the trays, about 29 parts of nitric nitrogen (in nitrites and nitrates) per 100,000. It is claimed for the process that it is capable, by continuous flow, of treating and purifying one million gallons of sewage per acre of tray-area in 24 hours.

Another filtering medium which has been used experimentally in Lichfield for the purification of the day-sewage is coal. The experiments made there on the large scale demonstrated an instant reduction in the effluent of albuminoid ammonia and of oxygen absorbed, but that no nitrification took place until some weeks after the coal filter-beds were in operation. The coal-filter was constructed by filling an excavated area of ground of a depth of $5\frac{1}{2}$ feet with coal to a depth of 5 feet, the bottom of which was laid with drains. The sewage, after the addition of alumino-ferric and lime, and after being passed into precipitation-tanks and freed from suspended matter, is then passed through the coal filter-beds, composed of particles of sizes from above downwards of $\frac{3}{8}$ths to $\frac{1}{8}$th of an inch. The results of the treatment are shown in the following analyses by the Public Analyst of Staffordshire.

Table XXXVI

Parts per 100,000

Constituent	Tank Effluent	Coal-Filter Effluent
Total solids	116·00	155·00
Free and Saline Ammonia . .	7·35	0·016
Albuminoid Ammonia . .	0·33	0·046
Nitrogen as Nitrates . . .	0·00	7·000
Chlorine	24·50	22·10
Oxygen absorbed in four hours, 80° F.	7·36	0·243
Appearances	Black	Clear and colourless
Smell	Very offensive	None
Reaction to litmus . . .	Slightly alkaline	Neutral

In Massachusetts, sand is used as the filtering medium, but the rate of filtration is only 100,000 gallons per day per acre.

Area of Filter-beds.—The extent of superficial area of filter-beds required in the bacterial process for the treatment of sewage per 1000 of population is not yet finally decided. Kaye Parry is of opinion that to obtain a good effluent of a previously clarified sewage, two acres of artificial filters for every million gallons of sewage per day are required. Baldwin Latham has estimated that the probable cost of artificial filters for Manchester would amount to £300,000 without including cost of purchase of land, working expenses, and renewals. A fair estimate of filter-area may be reckoned to be half an acre for a population of 1000 or 1500. At Barrhead, where the system has been installed to treat the sewage of 10,000 persons with a daily dry-weather sewage-flow of 200,000 gallons, the total area of contact-beds is 3 square poles 5 square yards.

Sludge or Deposit in Septic Tanks.—The remarkable feature in the bacterial treatment is the large disappearance by natural agencies of the sludge which is formed in the other processes. Although the Exeter tank had been in operation for more than four years it was found that the floor of the tank was but thinly covered with a fine deposit. At Barrhead, where the system has been working for some years, the deposit has formed to a depth of 30–36 inches at the inlets to the septic tank, grading downwards to 12–14 inches at the outlets, the deposit being very soft, and black in colour.

Effect of Storm-Water on the Process.—The English Local Government Board has framed certain rules for the works to be constructed for any system of purification, with reference to storm-water. The Board demands that provision shall be made as follows :—

1. To treat fully as ordinary sewage one volume of mixed sewage and storm-water equal to three times the daily dry-weather flow ;
2. To deal with the excess of storm-water up to six times the dry-weather flow, either by passing it through a special and separate storm-filter, or by delivering it on a special area of prepared land other than that in use for the treatment of the effluent from the ordinary tanks and filters. If such a storm-filter be provided, it should be of sufficient area to permit a rate of filtration of 500 gallons per square yard in 24 hours ;
3. That fixed bye-pass weirs should be constructed which will only come into action when the sewage is diluted with five volumes of storm-water.

Storm-water being a variable quantity might, at first sight, be considered to be a disturbing factor in the efficiency of the bacterial process, in respect that the increased velocity of flow of the sewage would prevent the organisms exercising their action. But in a proper installation, such increase of velocity is but trifling, and influences but little, if at all, the results. In the Barrhead works, the trade effluents do not constitute any part of the sewage, but storm-water is included, and provision is made therefor up to two thirds the requirements above indicated. The works were constructed to serve a population of 10,000 persons and to deal with a maximum flow of sewage of 400,000 gallons per day, the dry-weather flow being reckoned as half that quantity. The regulation of the rate of velocity of sewage through the works being placed at the outlet from the septic tanks, deposit or sediment is not likely to take place at the inlet, as would be the case if matters were reversed. As has been mentioned, the very opposite of this anticipation has been realised. With a volume of sewage three times greater than the dry-weather flow, or 600,000 gallons per day, the velocity in the tanks is only $1\frac{7}{8}$ inches per minute, and with a volume six times greater, or 1,200,000 gallons, $3\frac{3}{4}$ inches per minute, either of which velocities would be incapable of disturbing any solid matter which may have collected at the bottom of the tanks, or of dislocating the thick, tough layer of scum on the surface of the fluid contents.

Effect of Sewage-Purification Processes upon Pathogenic Microbes.—What is the fate of pathogenic organisms in purification processes? The view usually held, that in the fierce struggle for existence they succumb to the greater activity of other organisms, must be modified in view of recent researches. It has been proved beyond doubt by Houston and others, that certain pathogenic organisms come unscathed through any of the foregoing processes. Houston, founding upon experiments conducted for the recent Sewage Commission, affirms "that it is doubtful if any bacterial process in practical operation at the present time 'treats' or 'detains' the sewage for a sufficiently long period to allow of the complete destruction of all the pathogenic germs by bacterial agencies."[1] From his experiments upon the operation of the process at Barking and Crossness, he points out that *B. coli communis* and *B. enteritidis sporogenes* are nearly as plentiful in the effluents as in the crude sewage. Moreover his experiments with the Yeovil sewage show unmistakably that the anthrax bacillus passes unscathed, as do also its spores.

Respecting *B. typhosus* and *B. Choleræ Asiaticæ* the same has not yet been proved to demonstration. They are, however, less hardy and resistant than the former. From the experiments of Andrewes and Lewes in 1894[2] it seems well established that ordinary sewage does not constitute a congenial medium for their life and growth; indeed, even in the best circumstances, their life in sewage is limited but to days. On the other hand, since streptococci are abundantly found in effluents from bacterial beds—streptococci being comparable in resisting power with the organisms of enteric fever and cholera—it must be presumed that these latter will also survive the bacterial treatment and pass by the effluents. We have been able to corroborate Houston's results with respect to *B. coli communis* and *B. enteritidis sporogenes.* In the water of a small stream into which the effluents from coarse contact-beds of an installation are allowed to flow, these organisms were found by the author in great abundance.

ROYAL COMMISSION ON SEWAGE DISPOSAL

Much important work has been done by this Commission since its appointment in 1898, and although its work is still uncompleted, its Reports have proved of valuable assistance in clearing certain points regarding which Local Authorities and even Local Government Boards were in doubt.

Including the Interim Report, the Commission has up till the present issued six Reports, viz.: (*a*) Interim and First Report in 1902, (*b*) Second Report in 1902, (*c*) Third Report in 1903, (*d*) Fourth Report in 1904, (*e*) Fifth Report in 1908, and (*f*) Sixth Report in 1909.

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[1] *B.M.J.*, vol. ii., Aug. 18, 1900.

[2] *London County Council Report*, 1894.

It will be sufficient for our purpose if we confine our observations to the different findings contained in these Reports.

I. Interim Report, 1902.[1]

The conclusions of this Report were as follow, viz. :—

(1) That peat and stiff clay lands are generally unsuitable for the purification of sewage, that their use for this purpose is always attended with difficulty, and that where the depth of top soil is six inches or less, the area of such lands which would be required for efficient purification would in certain cases be so great as to render land treatment impracticable.

(2) That it is practicable to produce by artificial processes alone either from sewage, or from certain mixtures of sewage and trade refuse, effluents which will not putrefy, which would be classed as good according to ordinary chemical standards, and which might be discharged into a stream without fear of creating a nuisance ; and, therefore, there are cases in which the Local Government Board would be justified in modifying, under proper safeguards, the present rule as regards the application of sewage to land.

(3) That, generally speaking, the Rivers Pollution (Prevention) Act, 1876, has not resulted in the general purification of rivers in this country, due largely to the reluctance of Local Authorities to put the Act in force, but partly also to the difficulty which a Sanitary Authority experiences in proving that the pollution within its district comes from the district against which, or the person against whom, action is taken ; but that the Local Government Act, 1888, section 14 (1), and the Local Government (Scotland) Act, 1889, section 55 (1), give to County Councils in England and Wales and in Scotland respectively power to enforce the provisions of the Rivers Pollution Act, in relation to so much of any stream as is situated within or passes through their jurisdiction.

The Commission further draws the attention of Local Authorities to the provisions of the law whereby the Local Government Act, 1888, section 14 (3), and the Local Government (Scotland) Act, 1889, section 55 (3), give power to County Councils by Provisional Order of the Local Government Board to form Joint Committees for rivers pollution prevention purposes.

(4) That the simplest possible means should be provided for the adequate protection of rivers, and that either a separate commission, or a new department of the Local Government Board should be created, which should be a supreme Rivers Authority dealing with rivers and their purification with power to take action where Local Authorities fail so to do.

II. Second Report, 1902.[2]

This Report contains several valuable reports of different investigations undertaken by different expert observers of subjects coming within the scope of the work of the Commission.

Of these may be mentioned (*a*) the Manchester experiments in sewage-purification, (*b*) the bacteriological standards in relation to potable and non-potable waters, (*c*) the longevity of *B. typhosus* in sewage. (*d*) the effect of filtration in reducing the number of bacteria in sewage-effluents, (*e*) the pollution and self-purification of the river Severn. and (*f*) some of the chief methods used in the bacteriological examination of sewage and effluents.

III. Third Report, 1903.[3]

This Report deals chiefly with trade effluents and—

1. (1) With the right of manufacturers under the existing law to discharge

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[1] Cd. 685.

[2] Cd. 1178.

[3] Cd. 1486.

trade effluents into sewers, and with the uncertainty of the law thereupon.

The Commissioners arrived at the opinion that, unless the law is altered, differential treatment of manufacturers in this regard will continue, and, in consequence, trade will continue to be seriously hampered, if not, indeed, injured; that all manufacturers should be treated alike in this regard; and that it was practicable to secure greater uniformity than at present exists.

(2) With the practicability of purifying mixtures of trade effluents and sewage.

The Commissioners found on the evidence that sewage so mixed is more difficult to purify than ordinary domestic sewage because—

(*a*) the trade effluents are discharged into sewers at irregular intervals, thus causing considerable variations in the character of the sewage to be treated;

(*b*) these effluents may contain large quantities of solids in suspension, which tend to choke the purification-plant;

(*c*) the effluents may be very acid, very alkaline, or otherwise chemically injurious.

They were of opinion that, wherever practicable, the manufacturers should (*a*) remove the bulk of the suspended solids from the effluents, (*b*) neutralise the same, and (*c*) deliver the effluents into the sewers as uniformly as possible; and that if these conditions were observed, it was practicable in the great majority of cases to purify mixtures of sewage and trade effluents.

(3) With proposed alterations of the law.

The Commissioners were of opinion that the law should be so altered as to make it the duty of a Local Authority to provide such sewers as are necessary to carry trade effluents as well as sewage, and that the manufacturer should be given the right, subject to safeguards, to discharge trade effluents into the sewers of a Local Authority if he wishes to do so; provided that the safeguards should be of such a kind as to protect a small Local Authority against a large manufacturer, and to conserve the rights of riparian owners, and provided that no extra rate be put upon any manufacturer who submits his effluent to the aforesaid preliminary treatment, except where there are exceptional circumstances as regards volume, quality, or otherwise.

2. The need of establishing a Central Authority to settle differences between Local Authorities and manufacturers.

Differences may arise on any of the following points:—

(1) The refusal of a Local Authority to allow a particular trade effluent to enter their sewers;

(2) The refusal of a Local Authority to construct or enlarge sewers for the purposes of a particular manufactory;

(3) The nature of the general regulations as to preliminary treatment of effluent by manufacturer;

(4) The imposition of a special charge on the manufacturer, and its amount;

(5) The removal of sludge where manufacturer submits effluent to preliminary treatment.

On the evidence given before them, the Commissioners recommended unhesitatingly the creation of a properly equipped Central Authority in the interests of the trade of the country and of river-purification alike; and that this Authority should consist of (*a*) an Administrative Head, (*b*) a bacteriologist having special knowledge of the bacteriology of sewage, trade effluents, and water-supply, (*c*) a chemist with knowledge of the same from the chemical side, and (*d*) an engineer having a special knowledge of geology and water-supply.

The Authority should be provided with a fully equipped laboratory. It should have powers to conduct inquiries, to call witnesses, to enter premises to take samples of trade effluents, and to do all other necessary acts. Except with the permission of the Authority, neither counsel nor expert witnesses should be heard at its inquiries. It should be a new department under the Local Government Board.

In view of the fact that in many parts of England the pollution of rivers goes on unchecked notwithstanding the Rivers Pollution (Prevention) Acts, the Central Authority should also deal with river pollution, but not take the place of Local Authorities in protecting their rivers and sources of water-supply.

The Commissioners further recommended that Rivers Boards such as the Mersey and Irwell Joint Committee, the Ribble Joint Committee, and the West Riding Rivers Board, should be formed all over the country, the duties of which ought to include the supervision and inspection of water-supplies against pollution; that it should be the duty of the chief inspector of each Board to make annually a report on the work of the year, a copy thereof to be sent to the Central Authority; and that the Central Authority should exercise a general superintendence over the whole country respecting the prevention of pollution of water, should investigate all cases of pollution brought under its notice by the Rivers Boards, and, when pollution is proved dangerous to health, should notify the same to the company or Local Authority supplying the water.

IV. Fourth Report, 1904.[1]

This Report is mainly concerned with—

(1) the law in regard to pollution of tidal waters;
(2) the contamination of shell-fish by sewage effluents; and
(3) the possibility of communication of disease through shell-fish.

The remedies suggested by the Commissioners are as follow:—

(1) Purification of sewage before discharge into tidal waters;
(2) Seizure and destruction of unwholesome shell-fish exposed for sale; and
(3) Establishment of a competent Authority to deal with all tidal waters, to control foreshores, to close dangerous beds, ponds, and layings, and to require treatment of sewage; this Authority to be the Rivers Boards and the Central Authority.

V. Fifth Report, 1908.[2]

This Report deals with the Methods of Treating and Disposing of Sewage. The general conclusions arrived at by the Commission, based on various forms of evidence, were (*a*) that it is practicable to purify the sewage of towns to any degree required, either by land treatment or by artificial filters, and (*b*) that there is no essential difference between the two processes, for in each case the purification, so far as it is not mechanical, is mainly effected by micro-organisms. The two practical questions which arise for the consideration of any town proposing to adopt a scheme of purification are (1) what degree of purification do the circumstances of the town require in relation to the river or stream into which the effluent from the purification-works is to be discharged, and (2) how can that be most economically accomplished. Whatever may be the scheme chosen, the Commission state that they know of no case where the admixture of trade refuse with the sewage makes it impracticable to purify the sewage either upon land or by means of artificial processes, although in certain extreme cases special processes of preliminary treatment may be required.

The Commission say that sewage generally may be considered to consist of a mixture of saline matter in solution and nitrogenous and carbonaceous organic matter in solution and suspension, together with a certain amount of grit and mineral matter, and that the objects to be aimed at in purifying it are the removal of the suspended matters and the oxidation of the organic matter and ammonia;

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[1] Cd. 1883.

[2] Cd. 4278.

that the composition of various sewages varies to a large extent, and that these variations depend chiefly on the amount and nature of the water-supply, the number of water-closets, whether there exists a dual or a single system of channels, and what trade effluents (if any) are admitted into the sewers; that the most exact method of measuring or estimating the strength of a sewage is to ascertain the amount of dissolved oxygen taken up during the practically complete oxidation of the organic and ammoniacal matter therein; and that this dissolved-oxygen test differs from the oxygen absorbed from permanganate estimation in that it takes account of practically all of the organic matter, and not merely that of a particular kind; that this dissolved-oxygen test may be carried out in one of two ways:—(*a*) by diluting the sewage largely with good tap water, estimating the oxygen in solution in an aliquot portion of the mixture, and shutting off from the air the remainder in a bottle which is completely filled with the mixture. By allowing this to stand for at least two months, and making a fresh estimation of the dissolved oxygen at the end of that time, any difference will represent the amount of oxygen taken up by the sewage; or (*b*) by keeping the sewage, either in its natural condition, or slightly diluted with tap water, continuously aerated in a bottle, containing a measured excess of air. The Commission point out, however, that the length of time required for the completion of the test is a very serious disadvantage; even with special aerating arrangements the second method cannot be completed under twelve or more days.

1. *Preliminary Processes for Removal of Suspended Matters.*—The Commission are satisfied that it is more economical generally to remove a considerable proportion of the grit and suspended matter from the crude sewage before attempting to oxidise organic matters either on land or in filters. They point out that while it is true that at Leeds, Sutton, Hampton, Hendon (the Ducat filter), Market Drayton (the Ducat filter), and elsewhere, crude sewage has been satisfactorily purified in filters with almost complete absence of nuisance, in most of the places this had to be given up because of rapid choking of filters. *Screening* is advisable. Grit or detritus chambers or tanks for settlement of road detritus are also of advantage. Sedimentation-tanks, in which the sewage, untreated in any way, is allowed to settle for a time, have also been found most useful. At Leeds and Sheffield, for example, where in these tanks the sewage is allowed to settle for two or three hours, a fairly good tank liquor resulted. Where continuous-flow sedimentation is carried out, as at Clifton, Halton, Oswestry, and Dorking, and where the rate of flow per minute in inches was 1·7, 0·66, 3·40 and ·031 inches respectively, the reduction in the amount of suspended solids per 100,000 parts was from 49 to 24, 17·7 to 10·7, 32·0 to 15·8, and 20·8 to 10·1, respectively. The Commissioners are of opinion that such quiescent tanks should be used in parallel, in order that the period of actual quiescence should be as long as possible. Settlement of sewage by sedimentation does not give rise to serious smell while tanks are at work, but when the tanks are being sludged there is considerable smell.

Regarding the action of Septic Tanks, the Commissioners cannot uphold the claim originally made for these—that they solved the sludge difficulty by dissolving practically all organic solid matter. They find it proved that all such solid organic matters are not digested by septic tanks. Various estimates of the actual amounts digested were given for different places; for example, at Huddersfield, 38 per cent. of the solids were converted into gas or were digested, at Leeds 32 per cent., at Manchester about 25 per cent., at Sheffield 32·9 per cent., and at Birmingham not more than 10 per cent. At Exeter, where the Commission made observations extending over two years, the amount was 25 per cent., and at Ilford, about 30 per cent. In both of these last named places the sewage was domestic in character.

The second point found proved was that the effluent from the septic tank was bacteriologically almost as impure as the crude sewage on entrance. The third claim made for the septic tank—that the liquid therefrom was more easily treated than was sewage from which the solids had been merely removed—could not, after experiments, be upheld. Settlement of suspended solids in septic tanks is not usually very complete; in many places the tank liquor showed an average of 15 to 20 parts per 100,000. The actual amount was found to depend largely on the composition of the crude sewage. The longer a septic tank is run without cleaning out the sludge, the less *volume* of sludge will there be per million gallons of sewage treated, this being due to the closer settling of the sludge. With regard to the length of time a septic tank should be allowed to run without cleaning, the only guiding principle which the Commission can suggest is—so long as the suspended matter in the tank liquor shows no signs of affecting the filters detrimentally, and provided that it was never allowed to become more than one-third full of sludge. After a tank is cleaned out, either a portion of sludge should be left or it should be filled with septic tank liquor, if there be two, so that microbic fermentation may proceed apace. The Commission consider that the main objects of passing sewage through a septic tank, are three in number:—(*a*) settlement of suspended matter; (*b*) digestion of as much sludge as possible, and (*c*) equalisation of strength of sewage; that the most effective rate of flow is that which is sufficient to fill the tank once every 24 hours; that the closed tank possesses no advantages over the open tank, but where smells are apt to give rise to nuisance, the closed is better than the open; that at not a few places where the open septic tank was in use the smell was very marked, and, sometimes, gave rise to nuisance, as at Gosport, Guildford, and elsewhere; that in some places arrangements exist for removing suspended solids from the tank liquor, and in others, as at Dorking, the tank liquor is caused to pass through smaller tanks to which 2 to 3 grains of lime per gallon have been added, the effect being to rid the liquor of its offensive odour, and to purify a larger quantity of liquor per cubic yard of filter.

2. *Chemical Precipitation.*—The Commission believe that the opinion held by some that chemical precipitation methods of purification are obsolete forms of treatment is far from being well founded; that sewages which contain trade waste demand some form of chemical treatment before attempting to oxidise the organic matters; and that in an average domestic sewage, chemically treated and allowed thereafter to stand and settle for about 2 hours, it is practicable to reduce the suspended solids to from 1 to 4 parts per 100,000, and by continuous flow at an 8-hour rate, to from 3 to 6 parts per 100,000. They had under observation the effects or results of the use of the following precipitants:—(*a*) Lime; (*b*) Lime with ferrous sulphate; (*c*) Lime with alumino-ferric; (*d*) Alumino-ferric alone; (*e*) Alumino-ferric with blood, charcoal and clay (A.B.C. process); (*f*) Ferro-zone; (*g*) Ferric sulphate; and (*h*) Sulphuric acid. At most of the works where domestic sewage was treated, alumino-ferric was the precipitant used. They say of the A.B.C. process as carried out at Kingston, that it is a very efficient form of precipitation. The net result of the experiments with lime, lime and ferrous sulphate, and ferric sulphate and aluminum sulphate, was that ferric sulphate was on the whole the most manageable and the most effective precipitant, and of the Glasgow experiments, that ferric sulphate and lime always gave the best result. Sulphuric acid has proved of great use in those places where there is a large proportion of wool-scouring refuse in the sewage, as it neutralised the excess of alkali and separated the fat. It may be said generally that the kind and amount of precipitant or precipitants employed in any given case must be determined by the character of the sewage, especially with regard to proportion of trade effluents and the predominating character of these effluents. Where a sewage contains much brewery waste, as at Burton-on-Trent, lime would probably have to be used; or is very alkaline and greasy, as at Bradford, acid; or contains much tarry matter or matter having a restraining action on microbial activity, as at Manchester, septic tank treatment would probably be necessary. To be most effective, chemical precipitants do best work when added in the

form of a solution, and after addition, the mixture should be thoroughly mixed by mechanical agencies.

The Commission have done excellent public service in this report by indicating, under a series of hypothetical yet realisable conditions, the systems of purification which would be applicable, with their respective approximate costs. Such should prove of considerable aid to Local Authorities.

3. *Purification by Artificial Filters.*—Sewage-filters are divisible into two broad classes :—(*a*) contact-beds ; (*b*) percolating filters.

Contact-beds contain some filtering medium fitted for microbial activity and least liable to disintegration ; the sewage is held in the bed for some time, this period being called the period of contact ; and the bed after being emptied is allowed to remain empty for some time to enable re-aeration of filtering media to take place.

Percolating filters are filters in which the sewage is not held in volume but is permitted to percolate through the medium.

Both are capable of effecting some measure of oxidation of sewage, given proper construction and appropriate working.

For most efficient purification, suspended solids should be largely removed before sewage is submitted to these filters, especially if the filtering medium be of fine character.

But contact-beds may be divided into (1) coarse contact-beds, (2) medium contact-beds, and (3) fine contact-beds, depending on whether the material employed therein be 3 inches in diameter and upwards, half an inch to 1 inch in diameter, or ⅛-inch diameter respectively.

In the first, grit-settled sewage containing 20 to 30 parts of suspended matter could be treated at the rate of 1 to 1½ fillings per day, or if containing 30 to 50 parts of suspended solids per 100,000, at the rate of 1 filling per day ; in both cases the bed-material would require to be washed once every 18 to 24 months, and if secondary beds of medium-sized material be used with them, the secondary beds would have to be washed every 4 to 6 years ; in the *second or medium contact-beds*, tank liquids containing 10 to 15 parts of suspended matter could be treated at the rate of about 2 fillings per day, and the medium would require to be washed or renewed once every 3 to 5 years, liquids with 4 to 7 parts suspended matter at the rate of about 3 fillings per day, or, occasionally, of 4 fillings per day, and washing of material every 4 or 5 years, and liquors with 1 to 4 parts suspended matter at the rate of 4, and, occasionally, of 6 fillings per day, and washing every 8 years or thereby ; and in the *third or fine contact-beds*, only the last named kind of liquor could be safely treated.

Percolating filters are divisible into four classes, the first three of which correspond in respect of sizes of filtering media with the divisions for contact-beds, the fourth in this class being composed of filtering material of ⅛th-inch size and smaller.

In the coarse filter, grit-settled and screened sewage containing 30 parts of suspended matter per 100,000 parts could be treated at the rate of about 50 gallons per cubic yard per day, and the upper layers of the bed would require renewal, and the lower layers to be flushed, about every 2 years ; tank liquors with 10 to 20 parts suspended matters, at the rate of about 100 gallons per cubic yard per day ; liquors with from 4 to 7 parts suspended matter at a rate of 100–150 gallons per cubic yard per day, and liquids with 1 to 4 parts suspended matter, at a rate of 160 to 200 gallons per cubic yard per day.

In all these cases fungoid growths might develop on the surface of the beds.

With regard to the other three classes of percolating filters the screened sewage or tank liquids suitable for treatment therein would require to contain diminishing amounts of suspended solids to be filtered at a slower rate per day, and the bed-materials to be washed at shorter intervals than in the case of the coarse filters.

The Commission, while agreeing as to the fact that organic substances are changed in the contact-beds into CO_2 gas and ammonia, and while remarking that the purifying agents are bacteria, worms, insects, larvæ, animalculæ, offer no positive opinion as to the respective parts played by each in the process, but confirm the view already held that there is always a loss of nitrogen, as nitrogen gas, during the process. While contact-beds may be constructed by the excavation of stiff soil, the construction of the bottom of the bed should be such that the liquid may be drawn off quickly but quietly, hence it should be well under-drained and the outlet-valve should be easily accessible to enable ready sampling of effluent. With respect to depth of bed, the Commission think it inadvisable that they should be of greater depth than 6 feet or of a less depth than 2 feet. They found that the depth varied from 6 feet in Leeds to the least depth of 1½ feet at Oldham, the average being about 4 feet. The period of filling and emptying also varied, but they were of opinion that for effective work a contact of two hours' duration should be provided for and regularly observed, that the fillings should be as far apart from one another as practicable so that the maximum period for drainage and aeration between the fillings may be obtained, and that the filling and emptying be carried out as rapidly as possible. With regard to the use of automatic gear, the observations of the Commissioners and of others tend to the view that it is not possible to rely entirely on automatic apparatus, although within certain limits it may be advantageously used with much saving of labour. On the question of loss of capacity of contact-beds, the following factors are believed to enter into the result :—(*a*) disintegration of filtering material ; (*b*) consolidation of the same ; (*c*) deposition of colloidal matter ; (*d*) growth of organisms and development of animalculæ ; (*e*) volume of liquid passed on to the bed ; (*f*) insufficient rest ; (*g*) inefficient drainage, and (*h*) amount of suspended matter in liquid passed on to bed. Of these, probably the most important are disintegration of filtering material, consolidation of material especially in fine contact-beds, and suspended matter in liquid passed on to bed. In order to get rid of the accumulated suspended matter which has become incorporated in the filtering media, washing of the media must be periodically done.

As to the filtering materials employed, clinker and coke are those most in general use. Clinker has this advantage over the coke, that it is very hard, is non-friable, presents a large superficies because of its irregular shape and vesicular form, and is not liable to disintegration. Coke has given good results in several places ; but the experience of the Commission has constrained them to prefer clinker. With regard to Dibdin's slate-slab primary contact-beds, they came to the conclusion, after having examined the beds at Devizes, where they were used to treat screened sewage, that such beds must be regarded more as preliminary settling or septic tanks than as contact-beds. With respect to size of material composing contact-beds, they reached the opinion that it should not be too small if the liquid to be treated contains an appreciable amount of suspended matter, else it will choke the beds and retard drainage, as was found at Devizes and Hampton, where the fine contact-beds were composed of ¼-inch clinker. As a general principle, the safe rule was that the size of material was to be determined chiefly by the amount of suspended matter present in the liquid to be filtered, the larger that amount the coarser the material demanded, the smaller, the finer the material permissible. As to grading of material in contact-beds, they reached the view that it was as unnecessary as it was expensive to exercise too great refinement in grading.

Depth of Percolating Filters.—The results of experiments at Accrington, Leeds, and Salford on this subject went to support the view that the deeper the material the better the resulting effluent, but the Commission, basing their opinion on experiments made by them at Horfield and Ilford, came to the finding that " within somewhat wide limits of depth, and given ample aeration and good distribution, the same amount of work can be got out of a cube yard of coarse material whether it is arranged in the form of a deep or of a shallow percolating filter." But after further experimentation at Dorking, the general conclusion, in addition to that just quoted, at which they arrived was " that the deeper the filter the better the effluent. This holds both for fine and coarse material, assuming good distribution and aeration" ; and that "the extent of the purification effected by a percolating filter varies with the average length of time taken by the sewage liquor to pass through the filtering material."

Methods of Feeding Percolating Filters.—The object to be aimed at in feeding such filters is uniformity of delivery over the entire area. Any distributor should, therefore, comply with the following requirements :—(1) Distribute uniformly over entire filtering area ; (2) Should not be affected by atmospheric conditions, as wind, frost, snow, etc. ; (3) Should be able to adjust itself to large variations in flow, in small night-flow and in increased storm-flow ; (4) The dropping points should not be liable to be affected by stoppage by suspended matter in sewage or tank liquor ; (5) Should be easy to clean ; (6) The points at which moving parts are in contact with stationary parts of distributor, or with parts having a different motion, should, as far as possible, be separated from the liquid which is being distributed. The selection of a distributor will depend on head of water or other motive power, and cost of working. The Commission had under observation the following six forms of distribution :—(1) A sprinkler, which acts either automatically or by applied power ; (2) A stationary form of distributor composed of perforated pipes carried over filter-area ; (3) A form of distribution in which definite volumes are automatically delivered in flushes ; (4) Distribution by means of a very fine material laid on filter-surface, by means of which sewage-liquid is spread over filter-surface ; (5) Dripping-trays, invented by Wallis Stoddart, by which sewage-liquid is carried over filter-bed in perforated trays of corrugated iron, from which it falls in drips on filter-surface ; and (6) Tipping-troughs—also a stationary form—consisting of pivot-balanced troughs, so balanced that when full they tip up, distribute their contents on filter-surface, and resume their original position.

The observations of the Commission respecting these may be thus summarised : No. 1. Moving sprinklers. Unless driven by applied power, they are seriously affected in action by wind, and by severe frost and snow. Automatically acting sprinklers, when fed from a flushing-tank, adjust themselves to large variations of flow, but when acting continuously, without such a tank their rate of action can only be varied within narrow limits. Perforated-pipe sprinklers need a considerable amount of attention. No. 2. Distribution by perforated pipes or nozzles laid over a bed is almost always rather unequal. This method requires a considerable head of water for efficient working, and constant attention to keep pipes and holes clean and free. Watson of Birmingham, after comparison of different methods of distribution, has adopted the nozzle form. No. 3 would only be suitable in a limited number of cases. It is not well adapted for treatment of strong sewage. No. 4. This form does well for either weak or strong sewages ; but unless the fine material on the bed-surface is kept closely packed, the liquid is apt to pass too rapidly to the drains. Nos. 5 and 6. Dripping-trays and tipping-troughs are more suitable for small than for large installations. They can adapt themselves to variations in flow. Trays are better suited for weak liquids in large volume than strong liquids in small volume. Distribution is seldom perfect, and, therefore, it is best to have deep beds where they are adopted. Medium-sized or coarse material should be used. They require daily attention. Tipping-troughs are liable to be completely put out of action by severe frost, as at Little Drayton, and the Commission think that the same cause would affect dripping-trays, though not to the extent of complete cessation of distribution.

They state that "all forms of distribution on percolating filters are liable to give rise to nuisance from smell, if a strongly smelling liquor has to be dealt with. In the case of trays or tipping-troughs the smell is confined more or less to the immediate vicinity of the filter, and it may be largely done away with at small works by providing an inexpensive form of cover for the filter. The nozzle form of distributor is naturally the most liable to give rise to smell, but moving sprinklers are almost equally bad in this respect." They add that experience has not demonstrated that it is *necessary* for purposes of aeration to expose the sides of a percolating filter to the atmosphere in order to obtain good results.

Purification of Sewage by Land Treatment.—"There can be no doubt that where the soil is suitable and the area of land sufficient, organic matters in sewage can be thoroughly oxidised by land treatment." Effluents from land and from artificial filters chemically possess similar qualities. Of the eight sewage farms under observation by the Commission, the average purification achieved was about 78 per cent.; of seven contact-bed installations, it was 93·4 per cent., and of six percolating-filter installations, 99·4 per cent., if in the last two cases the suspended solids be left out of count. Generally speaking, effluents from land treatment were found to be better than from artificial filters, where the best land was being employed. Of the eight sewage farm effluents, Nottingham was the only one which did not putrefy on incubation. While there is no essential bacteriological distinction between effluents from land and those from artificial filters as presently used, the former usually contain fewer micro-organisms than the latter. With regard to the volume of sewage to be treated on land, the evidence pointed to a maximum rate of 30,000 gallons per acre, or 1000 persons per acre, in the case of the best land, after preliminary treatment, and 3000 gallons per acre, in the case of clay land, after settlement of the sewage, per 24 hours.

Where surface-irrigation and not filtration is employed, the total acreage required must be relatively much greater, thereby considerably increasing the prime cost of the installation.

With regard to the quantity of sewage which can be treated upon a unit area of land, the following are the chief determining factors:—(1) Whether surface-irrigation or filtration is to be followed; (2) Quality and depth of soil and subsoil; (3) Whether or not land is to be cropped; (4) Strength of sewage or sewage liquor; and (5) Degree of clarification of liquor. Where soil is suitable there is less need for preliminary settling of sewage, before application to the land; indeed, porous sandy or gravelly soils may treat crude sewage without detriment, although nuisance might arise from decomposition of surface-deposited excremental solids; but where soil is heavy, preliminary settling is advisable. Peaty land is entirely unsuited for sewage-purification. Disposal of sludge, however, is easy in land treatment as compared with treatment artificially. Land treatment absorbs much of the water which passes into the soil, especially if crops are grown, and this is true even in respect of surface-irrigation, especially in the summer months, or, indeed, drier months of the year. From land treatment about 60 per cent. of nitrogen disappears during the process of purification, the percentages being less by artificial-filter treatment. While even in land treatment there must, during the colder months of the year, be no inconsiderable loss of nitrogenous manurial matter, it is much better utilised than in artificial-filter installations, where, as is usual, the effluents are discharged into streams. This is also true of the phosphates and salts of potash. No proof was furnished to the Commission of any direct or wide-spread injury to health of persons living on or near sewage farms in the case of well-conducted sewage farms. This but corroborates the view contained in the report concerning the Berlin sewage farm, which is composed of 39,000 acres of sandy soil, with a resident population in 1905 of over 4000 persons. With respect to the danger of polluted water from wells in the neighbourhood of sewage farms, the Commission indicate that it would be unsafe to use water from shallow wells sunk in such neighbourhoods or to use water for potable purposes from any such existing wells. Deep wells sunk through an impermeable stratum would, doubtless, be quite safe, but wells sunk through fissured strata cannot be relied upon to yield safe water, no matter how deep they be, while wells sunk in the chalk would be highly dangerous in this respect. Copeman's report[1] on an outbreak of enteric fever at Fulbourn Asylum shows that the contaminated water was obtained from such a source.

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[1] Report, L. G. Board, 1905–1906. Appendix A. No. 6. pp. 146–169.

Disposal of Sludge from Sewage-Treatment

I. *By conversion into a marketable manure.*—Two processes for this purpose engaged the attention of the Commission :—(*a*) the manufacture of "native guano" at Kingston-on-Thames; and (*b*) the manufacture of "Globe Fertiliser" at the Glasgow Dalmarnock Sewage Works. The former is the product of the A.B.C. process. Unit for unit, the nitrogen and phosphate of this product were found to be less effective than when applied in ordinary artificial manures. The latter is the product of the sewage after treatment by lime and ferric sulphate, filter-pressing, and drying and grinding. The total yield of nitrogen per cent. in this product, as found by the Commission, was 1·30 per cent.; in our analyses (see p. 278), it was 1·9 per cent.; and the figure for phosphoric acid corresponds closely with our own.

II. *By Deposition in the Sea.*—London discharges its sludge in the Barrow Deep, 20 miles below Southend, Glasgow in the Firth of Clyde, about 3 miles below the Garroch Head, and Manchester and Salford in deep water outside the North-west lightship, about 25 miles north-west of Liverpool. Southampton sends its sludge by barge by way of Spithead to the sea about 3 miles from land.

III. *Pressing of Sludge.*—Many sewage authorities adopt this plan, which renders the sludge more easily handled. The pressed cake is either sold or given free to farmers, or is tipped or buried.

IV. *By Lagooning.*—This consists in simply filling an earth tank of varying depth, having a bottom layer of clinker, with wet sludge, and allowing the incorporated liquid to disappear partly by evaporation and partly by draining. When the solids are sufficiently dried, they are put on waste land.

V. *By Covering flat ploughed land.*—The sludge is simply flooded on the land to a depth of a few inches. This has been done with success in the Birmingham works.

VI. *By Burning.*—Most of the attempts to burn sludge after admixture with some combustible material have proved unsuccessful.

VII. *Extraction of Substances from Sludge.*—Bradford extracts the grease from the sludge to such purpose that the sale of the products now more than meets the working expenses of the tank treatment of the sewage. Owing to the wool-scouring products in the sludge, such a process is feasible.

VIII. *Destructive Distillation.*—As yet this process is largely experimental. From the sludge such products as oil and sulphate of ammonia are obtained. From the sludge of the town of Bury, for example, 37 gallons of oil, and 124 lbs of ammonium sulphate per ton of dried sludge were obtained.

Effluent Standards.—The tests for sewage-effluents in relation to standards have been based, first, on the amount of contained solids in suspension, and second, on the rate at which the effluent, after removal of suspended solids, takes up oxygen from water.

The Commission state provisionally for the guidance of Local Authorities that an effluent which complied with the following conditions would be satisfactory :—

1. That it should not contain more than 3 parts per 100,000 of suspended matter;
2. That, after filtration through filter-paper, it should not absorb more than—
    (*a*) 0·5 part by weight per 100,000 of dissolved or atmospheric oxygen in 24 hours;
    (*b*) 1·0 part by weight per 100,000 of dissolved or atmospheric oxygen in 48 hours; or
    (*c*) 1·5 parts by weight per 100,000 of dissolved or atmospheric oxygen in 5 days.

It will be observed that the method of estimating the oxygen absorbed in a given time is based upon a natural, and not a laboratory process, and the method suggested on p. 15 of this Report is summarily as follows :—

(*a*) Dilute the sewage largely with good tap-water; estimate the oxygen in solution in an aliquot portion of the mixture; allow the remainder to stand in a bottle which has been completely filled and in which access of air has been cut off. At the end of 24 hours, or 48 hours, or five days, as the case may be, make another estimation of the contained oxygen in a similar aliquot portion, and if there be any diminution in amount, the difference will represent the amount of oxygen taken up by the organic matter of the sewage; or

(*b*) Continuously aerate the sewage, without dilution or with slight dilution with good tap-water, in a bottle containing a measured excess of air.

For complete oxidation of sewage by the former method, a considerable time, two months or longer, is needed, but by a process invented by Dr Adeney (see p. 438, appendix vi. of Fifth Report) the time is much shortened and the amount of oxygen readily measured.

Adeney's Method and Apparatus for Estimation of Oxygen absorbed in Polluted Waters are as follow :—

The bottles *A* and *B* in Fig 109, are two flat and shallow bottles of equal capacity. Each is fitted with a cork previously soaked in melted paraffin. The cork in *A* is bored with two holes, one for a bent tube in which is a stopcock a_2, the bottle end of the tube being cut off flush with the lower edge of the cork. Through the other hole is passed a tube with capillary bore which ends nearly at the bottom of the bottle, and above the cork is continued into a tube of ordinary bore which is graduated in $\frac{1}{20}$ths c.c. Above the graduated portion the tube is enlarged into a bulb a_1, and is then bent on itself until it passes through one of the holes in bottle *B* where it stops. On the downward portion of this tube is a stopcock b_1. The cork of bottle *B* has likewise two holes through one of which is passed the tube just described, and through the other a capillary tube which is bent at right angles, the free end above the cork bearing a stopcock b_2, and the other end stopping close to the bottom of the bottle.

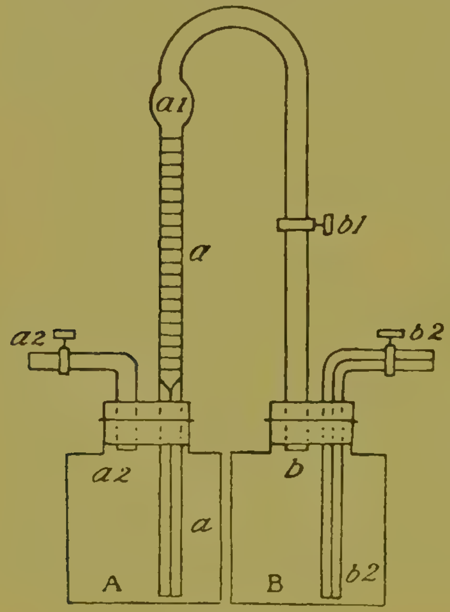

FIG. 109.

Modus operandi.—Partially fill bottle *B* with a known volume of the polluted water to be examined, to which has been previously added a small amount of magnesium dioxide to fix any free CO_2. Into bottle *A* put a similar volume of distilled water. The fluids in the bottles should be of the same room-temperature. The two bottles being alike in capacity, and the volume of added fluid being the same, the volume of air space above the fluid level in each will also be identical. Take out plug of stop-cock b_1, close stopcock a_2, and open stopcock b_2. Place corks and fittings into their respective bottles, and lay apparatus aside for a little time so that the whole may acquire the temperature of the laboratory. Note temperature of laboratory and height of barometer. The effect of stop-cock a_2 being closed at moment of fitting corks, etc., into bottles *A* and *B* is to cause the water in bottle *A* to rise into and through the capillary tube *a* to a point above the zero-mark of the graduated part of the tube above it. To bring back the water-level to the zero-point open cautiously stopcock a_2, and then close it. Keep stopcock b_2 closed. Replace plug of stop-cock b_1.

The pressure in bottle B will now be that of the atmosphere, and in bottle A will be that of the atmosphere plus the pressure due to the column of water in the capillary tube a, less the height to which the water had risen in it owing to capillary action.

If the water be much polluted, the apparatus is put into a mechanical shaker and thus the contents of both bottles are kept in gentle commotion. If, however, the water be weakly polluted, it is enough that the contents of the bottles be given an occasional shake with the hands. Apparatus should be kept at temperature 60°–65° F.

The principle of the apparatus depends on the fact that the atmosphere of the bottle A remains practically unchanged in composition during the time of experiment, and hence acts as a standard-pressure bottle. As the oxygen is absorbed from the air in the bottle B, the pressure of the atmosphere in it will be reduced in direct proportion to the loss of oxygen, since the magnesium hydroxide fixes any free CO_2. Therefore if the stopcock b_1 is opened, the water will rise in the tube aa above the zero-line in proportion to the loss of pressure in the bottle B. This height above the zero-mark gives, therefore, a means of calculating the volume of oxygen absorbed by the polluted water in the bottle B during the time of the observation thus:—

Let $v' =$ volume of oxygen absorbed from air in B, at initial temperature and pressure;

$V =$ volume of the air in A or B at commencement of observation;

$v =$ volume of water that rises above zero of scale of tube aa;

$p' =$ height of water in capillary tube a above the level it assumes by capillary action;

$p'' =$ height of water in graduated tube above zero-mark on the scale;

$p = p' + p''$.

$=$ Pressure of air in B at commencement in terms of the water barometer. The pressure in A at commencement will be $P + p'$.

$$\text{Then } v' = 2v + \frac{p}{p} V - \frac{p'}{p} (V - v).$$

Since v is generally small in comparison with V it may be neglected except where the utmost accuracy is desired. The equation then becomes—

$$v' = 2v + \frac{p''}{p} V.$$

The reason for adjusting the level of the water in the tube aa to the zero-scale at the beginning of the experiment is that, if it were not done, absorption of oxygen would take place from the air of bottle B before the water in the tube aa rose to the graduated portion.

The dimensions of the apparatus, according to Adeney, require to be varied as is the object desired by the experiment, as, for example, (1) to control pollution of waterways relative to fish life or to the interests of public health, (2) to determine the quality of an effluent, or (3) to determine the quality of raw sewage or of tank liquor.

Where crude sewage or even a strong tank liquor is to be examined, it ought to be diluted to five or ten times its volume with tap-water before it is placed in B, since such dilution prevents the evolution of nitrogen which might otherwise occur, crude sewage being generally super-saturated by free nitrogen. For determinations of small amounts of absorbed oxygen, as for the purpose of (1) above, the bottles A and B ought to have each a capacity of 1200 c.c., so that 1000 c.c. of the polluted water may be used and 200 c.c. of an air-space be left. The graduated part of the tube aa should have a capacity of 3 c.c. and its divisions should give readings of $\frac{1}{20}$th c.c., hence the tube ought to be 112 mm. long, and of 5·5 mm. bore, and the volume of the bulb a_1, about 1 c.c. For determinations as in (2) above, the bottle-capacities should be increased to

1500 c.c., using 1000 c.c. of the sample and leaving 500 c.c. of air-space, the graduated tube should have a total volume of 5 c.c., and hence should be about 186 mm. long with 5·5 mm. bore, the volume of the bulb a_1 being 5 c.c.; and for determinations as in (3) above, the bottle-capacities should be the same as in experiments for (2) but the graduated tube should have a total capacity of 10 c.c., being therefore about 225 mm. long and of 7 mm. bore, the bulb having a capacity of 10 c.c.

Adeney advises that the bottles to be used should be as shallow as possible, and the capillary portion of the tube *aa* as short as possible. He claims for the apparatus, when properly manipulated, accurate results with a minimum expenditure of time and labour.[1]

The advantage of the dissolved-oxygen test, according to the Commissioners, is that it is a biological process. It differs from the process of oxygen absorbed from permanganate in that "it takes account of the whole of the organic matter and not merely that of a particular kind." The final determination of standards has, however, been deferred meantime.

Pollution of Estuaries and Tidal Waters.—Although the Commission has not laid down any fixed rules regarding standard of effluent permissible for tidal waters, they are of opinion that in certain circumstances sewage should be purified before it is discharged therein, and that the Rivers Board should have power, subject to appeal to the Central Authority, to call upon a Local Authority to adopt some standard of purification where purification is necessary.

VI. Sixth Report, 1909.[1]

This Report deals exclusively with the disposal of liquid refuse from distilleries. This liquid waste consists of the residual liquids, all more or less polluting, from the following distillery-processes:—(1) the steeping of barley for melting purposes; (2) wash-water from washing of mash-tun, tun-room, and fermentation-vessels, in which last there is usually a good deal of lime with soluble and insoluble organic matter, as yeast cells; (3) "pot-ale" or "burnt ale," the product which remains in the still after the operation of distillation of the wash is finished; (4) "spent lees," the product remaining after distilling the "low wines" in the second still; and (5) the wash-water used in washing out the apparatus used in the distillery and distilling-rooms.

These vary in their polluting qualities. Pot-ale may be regarded as about 40 times as strong as ordinary sewage, and the steep-water in barley-melting as from 3 to 20 times as strong. Spent lees are much weaker than these, and wash-waters, perhaps, the weakest of them all.

The conclusions arrived at by the Commissioners, after observation and experiments, were as follow:—

1. That it is practicable to treat distillery waste liquors either on land or on filters so as to produce a satisfactory effluent;
2. That percolating filters are more efficient than contact-beds, but that before subjecting the products to this process they should be largely diluted and treated with lime;
3. That it is practicable to destroy pot-ale by heat, and also practicable to evaporate it and produce a valuable manure;
4. That in sewered towns, the liquid waste-products from distilleries should be allowed to enter the sewers, subject to regulations and safeguards as recommended in the Third Report;
5. That subject to the determination of the Central Authority, who shall finally fix standards, the Commission consider an effluent to be satisfactory which complied with the following conditions:
   (1) Did not contain more than 3 parts per 100,000 of suspended matter;
   (2) Was non-putrescible on incubation; and
   (3) Did not absorb, after filtration through filter-paper, more than 1·5 parts by weight per 100,000 of dissolved or atmospheric oxygen in 5 days.

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[1] Sewage Commission. Sixth Report, Appendix, p. 433. Cd. 4511, 1909.

The foregoing they consider to be quite a practicable standard of purification, but they think that in many cases a lower standard would be sufficient.

In considering the modes of disposal of these products, the Commission had in mind the fact that, owing to the situation of many distilleries, not a few of them discharged their effluents either directly into salmon rivers, or into tributaries of such rivers. The question of the welfare of fish came, therefore, under their purview. They accordingly made experiments at Coleburn with treated effluents on the hatching of salmon ova, and the development of young fish.

The purification-plant at this distillery consists of percolating filters on which the tank liquor is fed by an intermittent revolving sprinkler. The process consists of mixing all the waste liquids, diluting the mixture with water, and precipitating the solids with milk of lime in a tank, the volume of the mixed liquid being ultimately ten, and latterly five times the volume of the original pot-ale. The tank liquor thus produced is sprinkled over a percolating filter 24 feet in diameter and 12 feet deep, filled with good coke in pieces of sizes varying from one inch to three inches in diameter. The filtrate was then passed through shallow sand and gravel filters, one-inch thick layer of sand above and three inches of gravel beneath, the object being the removal of suspended matter. The resulting effluent contained less than one part of suspended solids per 100,000, alkalinity (as CaO) 12·50, dissolved oxygen at 27° C., in five days, 0·74, ammoniacal nitrogen, 0·03, albuminoid nitrogen, 0·14, total organic nitrogen, 0·36, nitrous nitrogen, 0·01, nitric nitrogen, 0·66, total nitrogen, 1·13. The fish and hatching experiments were carried out in four sets of tanks, through the first pair being passed the natural effluent, through the second 40 per cent. of effluent and 60 per cent. of water, through the third, a mixture of 4 per cent. of effluent and 96 per cent. of water, and through the fourth pair water only, as a control. In all the tanks the fish developed well, especially in the first and second, and in all the tanks the hatching of the ova was quite successful; thus proving that the effluent had no inimical effect on either ova or fish.

Refuse Disposal and Conservancy Methods

Notwithstanding the existence of a water-borne system of sewerage in a populous place, the solid refuse from houses, shops, streets, etc., remains to be disposed of. The frequent periodic removal of solid refuse of whatever kind, but chiefly from households (although it may include organic débris from shops, etc.), is technically called *scavenging*. The system, existing in some populous places, in which from such refuse materials are rescued which may be put to use, or which, after preparation, may be sold, is spoken of as a *conservancy* system. In smaller populous places, the disposal of refuse remains either in the hands of the Local Authorities, or is let to a contractor. In either case, it is a common practice to collect the refuse, which is of the most miscellaneous character, at a dumping-ground in the vicinity of the town, where the combustible material is burned in the open, the contents of privy-middens and stable litter being sold for agricultural purposes. Such a practice of dumping refuse is objectionable from the point of view not only of the amenity of the neighbourhood, but also from the existence of foul odours which proceed from such depôts. Especially is this the result where, in addition, slaughter-house offal is deposited, not to speak of the plague of rats attracted to the neighbourhood. In many of the older populous places, where different methods of refuse-collection have been in operation at different periods, the contents of privy-middens, ash-bins, etc., require to be collected. The problem is solved by the Local Authorities charging themselves with the duty of collection at short intervals of time. By the establishment of municipal depôts, to which the refuse is carted on collection, the manurial products are separately sold for agricultural purposes, all other débris which has a marketable value, as bottles, solder of tinned vessels, scrap iron, etc., is sold, and the remainder is disposed of by cremation in furnaces. In this way, hundreds of thousands of tons of refuse are got rid of yearly. Even the clinker which remains in the destructors has a marketable value. When broken by a mechanical crusher and sorted into grades, it commands a ready sale

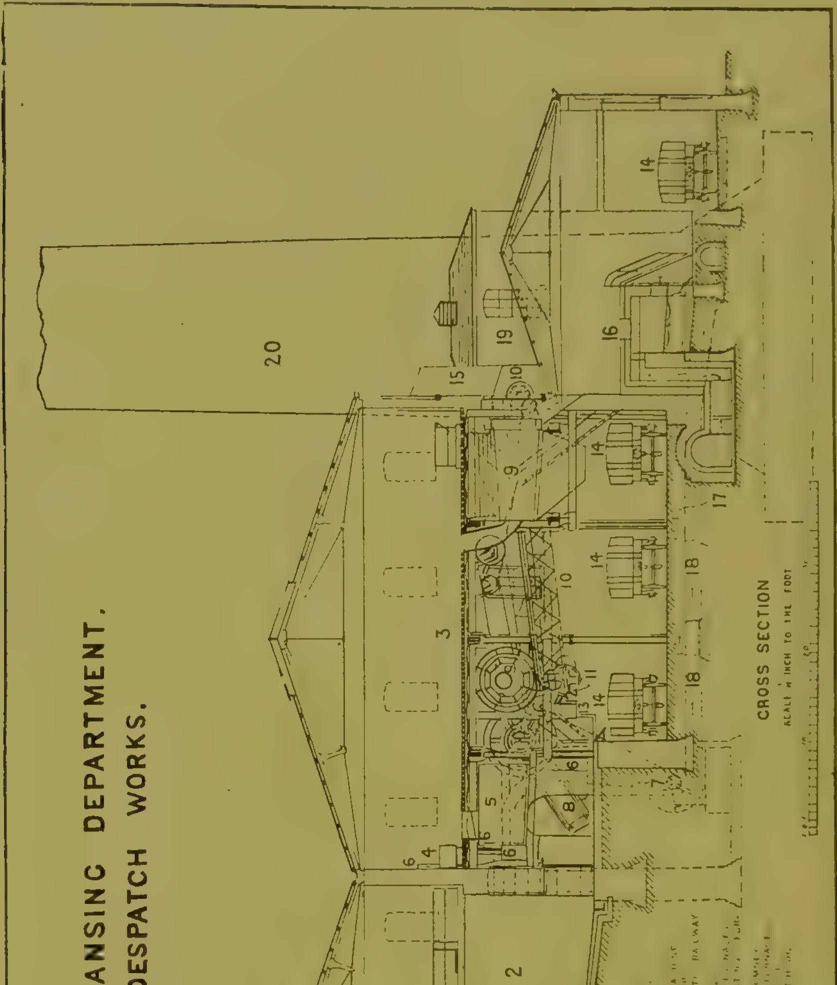

Fig. 110.

for concrete-making, and for contact-beds in sewage-works. Moreover, such works can be carried on at comparatively small expenditure, since all the heating power necessary for steam-raising and electric lighting in the works is obtained from the cinders and unburnt coal from the ash-pit refuse. Most large populous centres are now provided with, or are now instituting, these crematory furnaces or destructors ; indeed, up to the end of 1900, about 100 communities in Great Britain were employing incineration as the chief mode of refuse disposal. These destructors may be divided into two kinds, viz. : (1) Natural-draught, and (2) Forced- or Artificial-draught. Experience indicates that the latter are the best, the forced draught being obtained by steam-jet blowers. The main flue from these ought to be connected with a chimney of not less than 180 or more feet in height. Such works have now been carried to a high degree of perfection. By suitable planning, the different parts of the works are arranged on different levels to afford the greatest facility for working. By means of a roadway, the refuse is carted to the highest level. The semi-liquid or pasty mud from the streets is dumped into pits to permit of the draining away of the excess of water, after which the solid mud—manurial of itself—is further mixed with the fæcal contents of privy pans to form agricultural manure. Stable litter is similarly disposed of. Ordinary house-refuse from ash-bins and ash-pits is passed into a shoot, at the bottom of which is an endless travelling belt, by which the ashes and other material too large to be screened by a rotatory circular screen, is passed on to the incinerators. During their passage along this belt, marketable products are picked off by hand, for subsequent treatment and disposal. In the process of incineration to which all that now passes by the endless belt is subjected, it is important that fine dust should be got rid of, as it tends to form into a cake and thus hinders combustion. This is got rid of by the above rotatory screen. The incinerating furnaces are fed from the top with the material described, and are capable of reducing the weight of the refuse to 30 per cent. of the original weight. The substance left in the furnaces s a mass of slag-like clinker, which when broken up by a machine into different-sized pieces is used for pavement- and road-making, or when ground into fine powder by another machine and mixed with lime, forms excellent mortar for building purposes. Enormous heat is generated n these incinerators, temperatures of 1500° F. and upward being the rule. When such can be utilised for steam raising, enormous heating power is obtained. Provision is usually made in these works for the consumption of the smoke and fumes from the incinerating operations, by passing them over the fire and heat of the furnaces to branch flues which communicate with the main flue. The chimney by which the products of combustion are carried off, is usually about 150 to 180 feet n height. In this way, then, is the refuse of large populous centres got rid of safely and expeditiously, and on the whole, economically. Instead, however, of disposing of all ash-pit refuse in this way, the orporation of Glasgow leased a tract of useless peat-bog for the purpose of putting down thereupon the manurial street sweepings, etc. n a few years the whole tract was reclaimed and converted into good arable land, from which excellent crops have for years been obtained. This experiment at Fulwood, near Johnstone, is being repeated on a like tract of land about fifteen miles to the north-east of the city.

The privy-midden system in populous centres is contrary to good sanitation. It has been recognised that such places as adjuncts to dwellings are at least malodorous, not to speak of their being a positive danger to health when decomposition develops, which happens quickly. The privy, therefore, should give place to the water-closet, and the midden or ash-pit to the ash-bin. There cannot be any doubt that expeditious removal of the contents of these to the sewer and to the incinerator respectively is more conducive to the public health than the present practice. Offal from slaughter-houses, from fish- and other shops, like the ash-bin refuse ought to be removed daily, and may be economically disposed of after suitable treatment as manure. Street cleanliness ought to be a feature of populous centres. By means of street orderlies in busy streets or centres, horse and other droppings should be swept up and placed in small receptacles sunk in the edge of the roadway, which should be emptied daily. Streets ought not to be swept when dry on account of the enormous clouds of dust containing pathogenic organisms, which, doubtless, are raised, as some of the dust finds its way into the nearest inhabited dwellings. To save the double labour of watering first and mechanical sweeping afterwards, Glasgow has adopted the plan of washing the streets during the night by means of hose-pipes. This will in all likelihood effect a large improvement, and so far as the experiment has gone it has done this, but the binding material of the granite setts is being also washed away. What the result will be upon the deposition of solids in the sewers it is impossible yet to say, but it is not too much to predict that there is likely to be increase of sediment in certain sewers, owing to the increased amount of heavy solid matter which is thus being thrown into them in a state of temporary suspension. Moreover, to clean the streets by this method requires more water than most populous centres can always afford, or than some others can well spare even at any time.

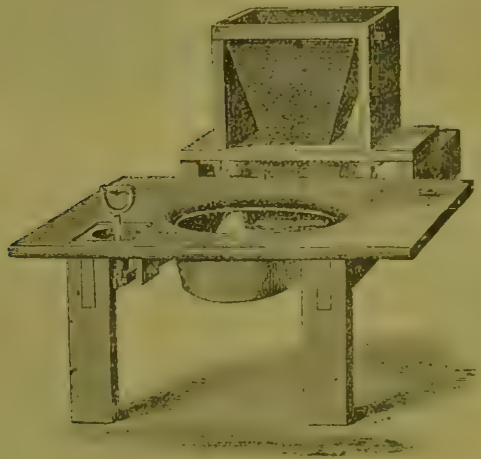

FIG. 111. — Moule's Earth - Closet. Introduced by the Rev. Mr Moule. The supply of earth is contained in the hopper seen at the back, and the necessary amount of dry earth may be projected into the pail by pulling the handle to the left of the figure.

In the absence of a water-carriage system, excreta must be got rid of in another way. The most primitive method is the privy-midden system, wherein the first-named convenience constitutes a part of the second, in respect that the discharges deposited in the one are allowed to mix with the ashes, food débris, etc., of the other. They are, however, foul-smelling receptacles, and should not be tolerated in populous places. In circumstances where some arrangement of this kind cannot be avoided, the two conveniences ought to be separated in the sense that the contents of each are removed separately; those of the privy by pans, which when removed more or less full under air-tight covers are replaced by empty and cleaned pans, and those of the ash-pit or midden, in the night by scavengers, and at short intervals of days. The ash-pit should not be permitted in a populous place to be placed nearer to any dwelling-house or occupied apartment than twelve feet. It should be roofed over to prevent contents becoming sodden by rain, and thus so far to hinder putrefaction; it should have an impervious floor to prevent soakage of subsoil with putrescent liquids; and it should not be commodious, so as to compel frequent removal of contents.

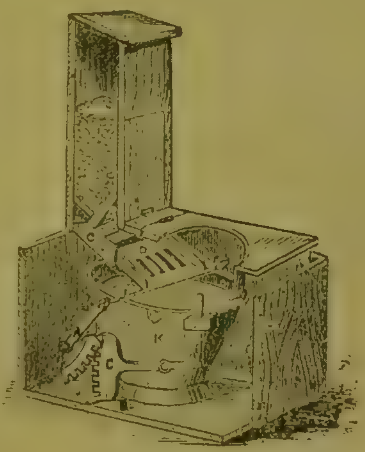
FIG. 112.—The Earth-Closet. British Sanitary Company's Model. The earth is introduced into the pail or receiver by the mechanical action of a lever which is set in operation by the user.

Earth - Closets. — However much better earth - closets would be than the pan-system just mentioned, their use is prevented in towns because of the difficulties of procuring easily or cheaply the earth necessary for their usage. At the same time, they have a distinct field of usefulness; as, for example, in connection with isolated houses, mansions, and smaller institutions, or in such circumstances as those in which a gravitation supply of water cannot be obtained at all, or only at unreasonable cost. The credit of the institution of the earth-closet is due to the Rev. E. Moule. Not only does the use of earth exercise a deodorant effect upon excreta, but dry decomposition without putrefactive odour is produced so long as the earth is dry; and if the mixed earth and excreta are further dried, the mixture may be used over and over again to form ultimately a valuable manure. The best kind of earth to use is comparatively dry garden or field humus. Sand or clay are much less serviceable, the former because of the want of deodorant properties, the latter because of its stiff, unmixable character.

Liernur's System.—This system, which has been adopted in some populous places in Holland and in Trouville, France, requires two different set of channels to be constructed—viz. one set for the convection of storm-water, the other for household excreta. The motive power for conveying the excreta from houses is compressed air. The excreta of each house find its way into a tank, and these tanks are connected by means of pipes with the central air-compressing machinery, by means of which the contents are periodically drawn to the works owing to the vacuum produced in the pipes. At the works, the excretal compound is reduced by boiling and evaporation to a dried condition called *poudrett* This is a valuable manure estimated in value at from £4 to £5 per ton. In the installation at Trouville, which has to deal with the night-soil and other household liquids of 20,000 persons during the season (Trouvill being a watering-place), it is expected that from the dried manure produced an income will be derived largely to meet, if not indeed fully to cover, the working expenses.

Allied to the subject of Sewage Disposal is that of River Pollution

The Acts of Parliament which deal with the prevention of pollution of rivers are—

1. Rivers Pollution (Prevention) Act, 1876 (39 and 40 Vict. cap. 75;
2. Rivers Pollution (Prevention) Act, 1893 (56 and 57 Vict. cap. 31;

I. The Rivers Pollution (Prevention) Act, 1876, was the outcome of the Reports of the Royal Commission on Pollution of Rivers. Its main enactments are as follow: —

1. *Prohibitory Sections.*

No person shall put or cause to be put or to fall, or shall unwittingly or knowingly permit to be put or to fall or to be carried into any stream, so as to interfere with its due flow, or to pollute its waters—

Solid Matters. Part I. Sect. 2.

(*a*) The solid refuse of any manufactory, manufacturing process, or quarry or any rubbish or cinders, or any other waste, or any putrid solid matter ;

Sewage Pollutions. Part II. Sect. 3.

(*b*) Any solid or liquid sewage-matter (unless he shows to the satisfaction the Court that he is using the best practicable and available means to render such sewage-matter harmless) ;

Manufacturing and Mining Pollutions. Part III. Sect. 4.

(*c*) Any poisonous, noxious, or polluting liquid proceeding from any factory or manufacturing process ; and

Part III. Sect. 5.

(*d*) Any solid matter from any mine in such quantities as to prejudicially interfere with its due flow, or any poisonous, noxious, or polluting solid or liquid matter proceeding from any mine, *other than water drained or raised from the mine* (unless, etc., as in *b*).

Object of the Act.

To make further provision for the prevention of the pollution of rivers and in particular to prevent the establishment of new sources of pollution.

Prosecuting Authority. (Sect. 6.)

Proceedings shall not be taken against any person under this part of the Act, *save by a Sanitary Authority*, nor shall any such proceedings be taken without the consent of the Local Government Board ; provided always that if the Sanitary Authority, on the application of any person interested alleging an offence to have been committed, shall refuse to take proceedings or to apply for the consent by this section provided, the person so interested may apply to the Local Government Board, and if that Board on inquiry is of opinion that the Sanitary Authority should take proceedings, they may direct the Sanitary Authority accordingly, who shall thereupon commence proceedings.

The conditions upon which consent of the Board is to be given are the following :—

(1) Regard must be had to the industrial interests involved, and to the circumstances and requirements of the locality ;

(2) Consent shall not be given to proceedings by the Sanitary Authority any district which is the seat of any manufacturing industry, unless they are satisfied, after due inquiry, that means for rendering harmless the poisonous, noxious, or polluting liquids, etc., are reasonably practicable and available under all the circumstances of the case, and that no materia

injury will be inflicted by such proceedings on the interests of such industry ;

(3) Any person against whom proceedings are proposed to be taken shall, notwithstanding the consent of the Board, be at liberty to object before the Sanitary Authority to proceedings being taken, and the Authority shall, if required in writing by the said person, afford him an opportunity of being heard against such proceedings being taken, so far as the same relate to his works or manufacturing process. The Authority shall thereupon allow such person to be heard by himself, agents, and witnesses, and, after inquiry, the Authority shall determine, having regard to the considerations laid down for obtaining the consent of the Local Government Board, whether the proceedings shall still proceed or shall cease and determine ;

(4) Where one Sanitary Authority take proceedings against an offender, it shall not be competent for another Sanitary Authority to take action against the same person till such reasonable time has elapsed wherein the offender might carry out the order of a competent Court.

The Act further provides :—

Section 7. That every Sanitary or Local Authority having sewers under their control shall give facilities for enabling manufacturers to empty their waste products into such sewers, except such products as would prejudicially affect the sewers, or the sale, application to land, or otherwise, of the sewage-matter conveyed in the sewers, or which would, from its temperature or otherwise, be injurious in a sanitary point of view, or where said sewers are only just adequate for the needs of the Sanitary or Local Authority.

Section 8. That every Sanitary Authority, subject to the restrictions named, shall have power to enforce the provisions of this Act in relation to any stream being within, passing through or by, any part of their district, and to institute proceedings in respect of any offence under this Act against any other Sanitary Authority or person, whether said offence is committed within or without the district of the prosecuting Authority.

Proceedings may also, subject to the restrictions named, be instituted in respect of an offence under this Act by any person aggrieved by the commission of such offence.

Proceedings shall not be taken until the expiration of two months after written notice of the intention to proceed has been given to the offender.

A competent court of jurisdiction may—

(1) by summary order require the offender to abstain from the commission of the offence, or to perform his duty where the offence is due to omission of performance of such duty ; or

(2) may insert in any order such conditions as to time or mode of action as it may think fit, and generally may give such directions for carrying said order into effect as may seem meet ; or

(3) may remit to skilled parties to report on the " best practicable and available means," the nature and cost of works, and apparatus required.

A certificate by an inspector of " proper qualifications " appointed under section 12 for the purposes of this Act by the Local Government Board, to the effect that the means used to prevent pollution from any of the aforesaid causes, are the best or only practicable and available means under the circumstances of the particular case, shall be held in all legal proceedings to be conclusive evidence of the fact, and such certificate shall run for a period of two years, and may be renewed for the like or any less period. Any aggrieved person may appeal against the finding of such inspector to the Local Government Board.

Nothing in the Act shall prejudice or affect any rights or interests existing or vested in any person or persons by Act of Parliament, law, or custom ; and nothing in this Act shall legalise any act or default which would but for this Act be deemed to be a nuisance or otherwise contrary to law.

Where any Local Authority or any urban or rural Sanitary Authority have been empowered or required by any Act of Parliament to carry any sewage into the sea or any tidal waters, nothing done by such Authority in pursuance of such enactment shall be deemed an offence against this Act.

There are certain important definitions in this Act—viz.

"Stream" includes the sea to such extent, and tidal waters to such point, as may, after local inquiry, and on sanitary grounds, be determined by the Local Government Board, rivers, streams, canals, lakes, water-courses, other than water-courses at the passing of this Act mainly used as sewers and emptying directly into the sea, or tidal waters which have not been determined to be streams.

"Solid Matter" shall not include particles of matter in suspension in water.

"Polluting" shall not include innocuous discoloration.

II. Rivers Pollution (Prevention) Act, 1893, was passed to explain the Act of 1876.

Section I. explains section 3 of the Act of 1876 with reference to drainage into streams, as follows :—

"Where any sewage-matter falls or flows or is carried into any stream after passing through or along a channel which is vested in a Sanitary Authority, the Sanitary Authority shall, for the purposes of section 3 of the Rivers Pollution (Prevention) Act, 1876, be deemed to knowingly permit the sewage-matter so to fall, flow, or be carried."

The Local Government Act, 1888, section 14 (1), and the Local Government (Scotland) Act, 1889, section 55 (1), give to County Councils in England and Wales and in Scotland respectively power to enforce the provisions of the foregoing Acts with regard to so much of any stream, as is situated within or passes through their jurisdiction; and section 14 (3) and section 55 (3) give power to the same Councils to form, by Provisional order of the respective Local Government Boards, Joint Committees for rivers pollution prevention purposes.

In 1892, the Lancashire County Council obtained from Parliament "The Mersey and Irwell Joint Committee Act, 1892," and in 1894 the Council of the West Riding of Yorkshire, the "West Riding of Yorkshire Rivers Act, 1894." In the latter Act, "solid matter" is specified as "the solid refuse of or the sweepings from any manufactory, manufacturing process, brickyard, mine pit-shaft, quarry, workshop, or shop, or any bricks, stones, gravel, sand, earth, mud, soil, ashes, cinders or clinkers, or any rubbish, or any deposit in a reservoir, mill-dam, water-lodge, or pond, or any sludge, or any solid sewage-matter, or any garbage or offal from a slaughter-house, or the carcase or portion of the carcase of any solid matter"; and *liquid sewage* "includes any liquid of an excrementitious character, blood, and the washings of a slaughter-house which contain blood."

It is not necessary under this Act to obtain the consent of the Local Government Board to prosecute in the case of pollution by solid matters or sewage, but that consent must be obtained to prosecute respecting pollution from manufacturing processes,

The Gas-Works Clauses Act, 1847 (10 and 11 Vict. cap. 15), section 21, imposes a penalty of £200 and of £20 *per diem* during continuance of offence, on any gas-company which fouls a stream with gas-washings, after twenty-four hours' notice has been given.

The Salmon Fisheries (Scotland) Act, 1862, section 13, made provision for the prosecution of manufacturers who polluted salmon rivers to the injury of fishing and fish life, but in the Amending Act of 1868, the wording of the section was so changed that the power became virtually useless for purposes of prosecution.

Having been engaged during the last twenty years in prosecutions dealing with pollution of rivers, and having devoted much attention to the subject, the author may refer the reader who desires to pursue the subject relative to Scotland to the following papers.[1]

It will be well for the student to compare the foregoing Act with the sections of the principal Act, sections 222 and 223 of the Burgh Police (Scotland) Act, which refer to pollution of streams flowing through or on the boundary of a burgh (*vide* p. 320), with section 17 of the Public Health Act, 1875 (p. 333), and with section 116 of the P. H. (Scot.) Act, 1897 (p. 317).

River Pollution by Sewage

Attorney-General v. *Birmingham, Tame, and Rea District Drainage Board*

The decision in this case is one of the most important which has been made of recent years on the subject of sewage-pollution. It was held by the judgment of the Court of Appeal that a Local Authority may discharge polluting matter into a natural stream so long as the entering polluting matter is not more foul than the water of the stream itself. The facts of the case, put briefly, are these :—In 1899, the Attorney-General, at the relation of the Tamworth Corporation and the Tamworth Rural District Council, raised an action against the defendants, a Joint Board established under section 279 of the Public Health Act, 1875, for the purpose of treating the sewage of the city of Birmingham and certain adjoining districts. The action was one of injunction to restrain the defendants from conveying sewage or filthy water into the River Tame from their sewage farm until such sewage or filthy water had been freed from all excrementitious or other foul or noxious matter as would affect or deteriorate the purity and quality of the water in that stream. Injunction was granted in November, 1907, after trial, by Kekewich, J., in the lower Court. The defendants appealed to the Court of Appeal.

In 1907, the method of treating the sewage on their sewage farm by the defendants was partly by passing it over bacteria beds and partly by downward filtration in lagoons. After that date (November 1907), the defendants began new works—viz. the construction of additional bacteria beds, and a storm-water tank. On the completion of these, which were intended to satisfy the provisions of section 17 of the Public Health Act, the appeal came on for hearing.

The evidence at the hearing being so conflicting, the Court remitted to Sir William Ramsay to inquire and report whether the effluents from the sewage-works of the defendants which entered the river were, before entering, freed entirely or to any extent from excrementitious or other foul or noxious matter such as would affect or deteriorate the purity of the water in the river (*a*) at the point of entry, or (*b*) within a distance of 600 yards therefrom.

Sir William Ramsay, after examination of the *locus* and upon the results of analyses he had made, reported to the Court of Appeal as follows :—"If 'excrementitious matter' means actual excrement, whether fæces or urine, then, of course, my reply is that it is absent. But if it means partly or wholly oxidised fæces or urine, the reply must be that there is some present. This definition would apply, though in a much less degree, to the water drunk by the greater part of the population of London, which is drawn from the Thames and the Lea, and these rivers are polluted by large volumes of sewage effluent from the towns on their banks. It is needless to say that the sewage undergoes complete purification before it enters the rivers, and also that the water is further purified by storage in reservoirs, and filtration through sand to such an extent that no danger is to be anticipated from drinking it. Dismissing these theoretical views as hardly applicable, it seems to me that the real question to be decided is: Are the waters of the Tame and the Rea before they receive the effluent from the Birmingham Sewage Works purer or less pure after the effluent has been added?" Having indicated from the analyses he had made the answer to which these pointed, he adds: "To sum up, my opinion is that the river is not made fouler by the entry of the Birmingham effluent. To adopt the terms of the reference: the sewage-effluents from the defendants' works which enter the River Tame are to such an extent freed from excrementitious matter and other foul or noxious matters that they do not affect or deteriorate the 'purity' of the water in such river (1) at the points of entry, or (2) within a distance of 600 yards therefrom."

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[1] *Author. Proc. Roy. Philosoph. Soc. Glas.* 1896–1897 } On Pollution of
Ibid. 1906–1907 } Scottish Rivers.

On behalf of the Attorney-General it was contended (1) that when the injunction was granted there was ample justification, and that the Court of Appeal had no power to discharge or suspend a properly-granted injunction; and (2) that by section 17 of the Public Health Act, it was intended to prohibit the discharge of any polluting liquid into any natural stream, which even on the face of Sir William Ramsay's report, was now being done. The defendants contended that having carried out works the effect of which prevented any deterioration of the water of the river, they were no longer committing an offence, and the injunction ought, therefore, to be removed.

Three judgments were given by different judges. Cozens-Hardy, M.R., noted that Section 17 of the Act read as follows:—"Nothing in this Act shall authorise any Local Authority to make or use any sewer, drain, or outfall for the purpose of conveying sewage or filthy water, into any natural stream or water-course, or into any canal, pond, or lake, until such sewage or filthy water is freed from all excrementitious or other foul or noxious matter such as would affect or deteriorate the purity and quality of the water in such stream or water-course, or in such canal, pond, or lake"; and he asked the very pertinent question. "Is that an absolute prohibition against conveying filthy water into any natural stream, or is it only a prohibition against conveying filthy or sewage water in such a manner as to prejudicially affect or deteriorate? It seems to me hardly reasonable to say that a man can be guilty of a statutory offence under this section if he has improved the water by that which he casts into it. I think, therefore, that it is not true to say that there has been a statutory offence if the defendants have put into the river some water which does contain a certain amount of filth, although it is so much better than the rest of the water which was in it before, that upon the whole it improves the character of the water. In other words, it cannot be said to deteriorate the purity of the water; on the contrary, it benefits it, and we must read the word 'affect' in the sense of *prejudicially* affect or deteriorate the purity and quality of the water. That being so, what ought we to do in this case ? I cannot fail to regard this : that the defendants are a public body discharging a most important function, that they have spared no money . . . and that they have done the best they could, with the result that instead of damnifying they have benefited the river. In these circumstances is it right to say that this body should go on discharging their duties with a sword over their heads in the shape of a perpetual injunction ? I think not. It may be that in the order which we propose to make we are going beyond anything that has been done in any previous case which is reported, but I think that the order which we propose will, while removing the sword over the heads of the defendants, and while enabling them to discharge their duties without the prejudice created by such an injunction, impose upon them such obligations as the statute desires should be imposed upon them, and will give the plaintiffs all such rights as they ought to have."

Fletcher Moulton, L. J., said : " I am of the same opinion, and I agree that this case raises a point of great importance to Local Authorities and to the public generally. The difficulty of dealing with sewage now that our towns have grown so large is very great, and seeing that sewage is now nearly all water-borne, and that it must, therefore, go down natural streams to the sea, the terms and restrictions which have been put by the Legislature upon the discharge of sewage into these natural streams become questions of great importance ; and it is incumbent on the Courts to see that they do not make the remedies which are in their hands for compelling these bodies to do their duty in this respect too onerous, by pushing beyond their legitimate meaning the legislative provisions as to purity ; otherwise the task of the Sanitary Authorities would be made impossible to perform. . . . I wish to deal with the question of what is excrementitious or other foul or noxious matter. We all know that excrementitious matter, being of organic origin, is liable to change, and if we are to take excrementitious matter to mean unchanged fæces or urine, then the defendants do not offend, because in their effluent there is none such. . . . Therefore what is present is more or less completely oxidised or burnt up excrementitious matter. If we were to say, therefore, that the statute meant that everything that had an excrementitious origin remained, no matter what changes supervened, excrementitious matter still, it would be perfectly impossible to purify water that had once been used as sewage, because the processes of purification do not remove nitrogen and the oxygen and the carbon which existed in the excrementitious matter that was originally put into the water : they only change their combinations. That which was put into the water must substantially remain there, and would remain there all the time. Consequently you cannot say that because there is matter which is derived from excrement, there is therefore excrementitious matter present. That would be a ludicrous interpretation of the section. . . . The test taken by the Legislature is an excellent one. They have said you may not discharge into a stream that which makes it worse. The consequence is that if by carefully applying purifying processes to the upper waters of the stream those waters become more and more pure ; then those that discharge into the lower waters of that stream must improve their methods so that they do not interfere with that improvement. Sir William Ramsay finds in general a most remarkable state of things with regard to this effluent. It is fully oxidised, much better oxidised than the water into which it was put, and he comes to this conclusion that the effluent does not deteriorate the stream; in fact, it rather improves it. He points to the existence of green growth in the river, and gives abundant reasons for his coming to the above conclusion. But it is the conclusion which is really important to us, and therefore I am satisfied that at last the admitted zeal of the defendants and their desire to perform their statutory duties have led them, thanks to the improvements in modern science, to a successful result, and that therefore the offence against this section has ceased."

Farwell, L. J., concurred.

The Court thereupon unanimously made the following order:—"It appearing that the state of things existing at the date of the judgment has since been changed by means of the permanent works constructed by the defendants, so that there is no longer any breach of the statutory provisions contained in Section 17 of the Public Health Act, 1875, and the defendants undertaking to use their best endeavours to prevent in future any breach of such provisions, discharge the injunction. The appellants to pay the costs of the appeal." [1]

[1] L. R. 1901. 1 Ch., pp. 52–56.
Jour. Roy. Inst. of Public Health, vol. xvii. No. 3. p. 186 *et seq.*

CHAPTER IX

LAW CONCERNING (1) SEWERAGE, (2) DRAINS AND HOUSE-DRAINAGE AND (3) SCAVENGING

Scotland.

The law is contained in the following Acts of Parliament :—

1. Public Health (Scotland) Act, 1897, Part VI. ; Sections 101–123 ;
2. Burgh Police (Scotland) Act, 1892 ; Sections 215–237 ;
3. Burgh Police (Scotland) Act, 1903, Part I. ; Section 25 ;
4. Burgh Sewerage, Drainage and Water Supply (Scotland), Act, 1901 ;
5. Local Government (Scotland) Acts, 1889, and 1894.

I. Public Health (Scotland) Act, 1897.

Sewers to be vested in Local Authority.

Section 101. All sewers existing within a district, not being private property, or not being under management of persons appointed by the Crown or by any Act of Parliament or Provisional Order, and all appliances pertaining thereto, shall be vested in the Local Authority.

Power to L. A. to purchase sewers.

Section 102. Gives power to L. A. in terms of sections 144 and 145 of this Act to acquire rights and powers vested in any person to make sewers or to use any sewer, with or without buildings, or other things pertaining thereto, and to make compensation for rights or for damage done.

Power to L. A. to construct sewers, and other works. Sewers to be cleansed.

Section 103. Gives power to L. A. to construct *within their district*, and when necessary for outfall, distribution, or disposal or treatment of sewage, *without their district*, such sewers as they may think necessary for keeping their district properly cleansed and drained.

They may carry such sewers through, across, or under any public or other road, street, or place, or under any cellar or vault under the foot-pavement or carriage-way, and, after reasonable notice, into, through, or under any lands whatsoever. They may, from time to time, enlarge, lessen, alter, arch over, or otherwise improve, or close up or destroy, all sewers vested in them, provided no nuisance is created by such operations.

If any person is thereby deprived of the lawful use of any sewer, the L. A. shall provide another sufficiently effectual for his use. L. A. shall keep sewers so as not to be a nuisance, and for this purpose may construct and place, either above or below ground, such reservoirs and other works as may be necessary, and may, subject to the provisions of the Rivers Pollution (Prevention) Acts, cause such sewers to communicate with or be emptied into such places as may be fit and necessary either *within* their district, or if necessary for purposes of outfall, distribution, disposal or treatment of the sewage, *without* their district, and to cause the sewage and refuse therefrom to be collected for sale or for any purpose whatsoever, but so as not to create a nuisance.

L. A. to give notice before commencing sewage-works without their district.

Section 104. The L. A., three months at least before commencing construction of any sewer or other work for sewage purposes without their district, shall give notice of intended work by advertisement in one or more local newspapers or by handbills circulated in the district. Said notice to describe the nature of the intended work, to state intended termini of the same, and to state the names of the parishes, public roads and streets, and other lands through, across, and under or on which the work is to be done, and shall name a place where a plan of proposed works is open for inspection at all reasonable hours.

A copy of said notice shall be served on owners or reputed owners, tenants or reputed tenants, and occupiers of said lands, and on the Local Authority and County Council where such district is situated.

In case of objection, work not to be commenced without sanction of Board.

Section 105. If any owner, etc., objects to such work and serves notice in writing of objection on the L. A. at any time within said three months, the intended work shall not be commenced without the sanction of the Local Government Board after inquiry, unless such objection is withdrawn.

Inspector to hold inquiry and to report to Board.

Section 106. The L. G. B. may, on application of the L. A. desirous of constructing such work, appoint an inspector to make inquiry on the spot into the propriety of the intended work and into objections thereto, and to report to the Board on matters with respect to which such inquiry was directed, and on receiving the report of such inspector, the Board may make an order disallowing or allowing the intended work with such modifications (if any) as they may deem necessary.

Protection of railways, etc., in sewer-construction.

Section 107. Contains provisions for the protection of railways, canals, bridges, etc., in construction of sewers.

Empowers L. A. to utilize sewage.

Section 108. The L. A. may from time to time, for the purpose of utilising sewage, agree with any person as to the supply of such sewage or the distribution or disposal or treatment thereof over land, and as to the works to be made for the same, and as to the parties to execute the same and to bear the costs thereof, and as to the sums of money, if any, to be paid for such supply; provided that no contract shall be made for the supply of sewage for a period exceeding five years, unless with authority of the L. G. B., and not for any period exceeding twenty-five years.

The L. A. may, in terms of sections 144 and 145 of this Act, contract for, purchase, or take on lease any lands, buildings, etc., for the purpose of receiving, storing, disinfecting, distributing, or disposing or treating sewage.

Power of Entry.

Section 109. In case it shall become necessary to enter, examine, or lay open any lands or premises for the purpose of making plans, surveying, measuring, taking levels, examining works, ascertaining course of sewers on drains, making or repairing, altering or enlarging sewers or drains, or other purposes ancillary to the powers herein given as to sewers or drains, and the owner or occupier refuses or withholds access and leave to perform the said operations, the L. A. may, after written notice to such owner or occupier, apply to the Sheriff who, if no sufficient cause be shown to the contrary, shall grant warrant to the L. A., their officers and others thereby authorised, to enter and do all or any of the works or operations aforesaid at all reasonable times in the daytime.

Power of owners or occupiers to drain into sewers of Local Authority, provided that sewage will not cause damage to sewer or cause a nuisance.

Section 110. Any owner or occupier within the district of a Local Authority, liable for the public health general assessment or special sewer assessment, shall be entitled to cause his drains to empty into the sewers of such L. A. on condition of his giving 20 days' previous notice of his intention so to do to the L. A. He must comply with the regulations of the L. A. regarding mode of communication with sewers, and be subject to the control of any person appointed by the L. A. to superintend the making of such communications. Provided always that the sewage to be added is not of a nature to cause damage to the structure of the sewer or, by admixture with the sewage therein, to cause a nuisance.

Use of sewers by persons beyond district.

Section 111. Any owner or occupier beyond the limits of the district of a Local Authority, or within said limits, who is not liable for the public health general assessment or special sewer assessment, may cause any sewer or drain from his premises to communicate with the sewer of the Local Authority provided always that such sewer of the Local Authority and the works connected therewith are of sufficient capacity and otherwise suitable for receiving such additional drainage; and that upon such terms and conditions as may be agreed upon between owner or occupier and such Local Authority, and any dispute which may arise under this section shall be determined summarily by the Sheriff. Provided always that the additional sewage is not of a nature to cause damage to the structure of the sewer or, by admixture with other sewage therein, to cause a nuisance.

Penalty for making unauthorised drains.

Section 112. Every person, not being authorised by the L. A., who shall make a drain into any sewer vested in the L. A. shall be liable in a penalty not exceeding £5, and the L. A. may close such communication between drain and sewer, and may recover summarily from the offender any expenses incurred by them.

Estimates for work to be taken.

Section 113. Before entering into any contract for executing any such work as hereinbefore or after mentioned, falling under this part of the Act, or connected with sewage or drainage, if the expense may exceed £30, the L. A. shall procure from a surveyor an estimate of the probable expense of constructing the same in a substantial manner, and of the yearly cost of maintenance; and such surveyor shall accompany such estimate with a report as to the most advantageous mode of constructing such work.

No buildings to be erected over sewers, etc.

Section 114. No building, unless with the consent of the L. A., shall be built over any sewer belonging to the L. A., and no vault, arch, or cellar, or other structure, and no pipes shall be laid so as to interfere with any such sewer.

Sewers and drains to be trapped.

Section 115. All sewers and drains, public and private, shall be sufficiently trapped and ventilated by the persons to whom they severally belong to the satisfaction of the L. A.

Distilleries and other works to make reservoirs within premises for depositing refuse of such works.

Section 116. The owners or occupiers of distilleries, manufactories, and other works shall be compelled, when possible, to dig, make, and construct pools or reservoirs within their own ground or as near their works as possible, for receiving and depositing the refuse of such works so far as offensive or injurious or dangerous to the health of those living in the vicinity thereof, or to use the best practicable means for rendering the same inoffensive or innoxious before discharging it into any river, stream, ditch, sewer, or other channel.

Prohibition against interrupting free flow of sewage.

Section 117. It shall not be lawful for any person to throw or suffer to be thrown or to pass into any sewer of a L. A., or any drain communicating therewith, any matter by which the free flow of sewage or surface or storm water may be interfered with, or by which such sewer or drain may be injured. Penalties for offence and for daily continuance of offence.

Prohibition against placing carcases in any water.

Section 118. It shall not be lawful for any person to throw or suffer to be thrown into any running water, spring, well, lake, pool, reservoir, drain, or ditch, the carcase of any animal or part thereof, and any person offending against this section shall be liable to a penalty not exceeding £10.

Drain discharging below low-water mark.

Section 119. The L. A. may order, when considered necessary for the public health, any drain to be discharged below low-water mark, with consent of Board of Trade and Commissioners of Woods and Forests.

As to drainage of houses without drains or adequate drains.

Section 120. If a house, distillery, manufactory, or other work within the district of a L. A. is without a drain or without such drain as is sufficient for effectual drainage, the L. A. may, by notice, require the *owner* of such house, etc., within a reasonable time therein specified, to make a sufficient drain emptying into any sewer which the L. A. are entitled to use, and with which the owner is entitled to make a communication, so that such sewer be not more than 100 yards from the site of the said premises of such owner; but if no such means of drainage are within that distance, then emptying into such covered cesspool or other place, not being under any house, as the L. A. may direct. On failure by owner to comply, the L. A. may, at the expiration of the time specified in said notice, do the work required and recover summarily the expenses of so doing from such owner. Provided that where in the opinion of the L. A. greater expense would be incurred in causing the drains of two or more houses to empty into an existent sewer pursuant to this section than in constructing a new sewer and causing such drains to empty therein, the L. A. may construct such sewer and require the owners of such houses to cause their drains to empty therein, and may apportion as they deem just the expenses of construction among the owners of the several houses, and may recover summarily such sums so apportioned, any difference to be determined summarily by the Sheriff.

Local Authorities may combine as to sewerage.

Section 121. Two or more Local Authorities may, with the sanction of the L. G. Board, combine together for the purpose of executing or acquiring an interest in or maintaining any works by this Act or any other Act authorised in regard to sewerage or drainage that may be for the benefit of their respective districts.

Special drainage districts.

Section 122. (1) Upon requisition to that effect made in writing by a Parish Council or by not fewer than ten ratepayers within the district of a L. A. not being the Local Authority of a burgh, the L. A. shall be bound to meet after 21 days' notice, or, if the L. A. itself so resolve, it may meet after 21 days' notice, and shall, whether sewers or drains have been already constructed or not, consider the propriety of—

(*a*) forming part of their district into a special drainage district ; or

(*b*) enlarging or limiting the boundaries of a special drainage district ; or

(*c*) combining a special drainage district with another special drainage district ; or

(*d*) enlarging or limiting the boundaries of both or either of such special drainage districts, and combining the same or parts thereof ; or

(*e*) determining that any special drainage district shall cease as such, or that any combination shall cease ; and the resolution of the L. A. shall determine all questions regarding the payment of any debt which may affect any district or special drainage district and the right to impose and the obligation to pay any assessment affected by such determination, and shall fix the date at which such determination shall take effect ; such resolution shall be published in one or more newspapers circulating in the district, or by the posting of handbills throughout the district ; a copy of said resolution shall be forthwith transmitted to the Board, and where the L. A. is a district committee, to the County Council ; and the production of such newspaper or handbill, or a certificate under the hand of the clerk of the L. A. (whose signature need not be proved), shall be sufficient evidence of such resolution ; and within 21 days after date of first publication of such resolution it shall be competent for any person interested to appeal against the resolution, whatever its terms may be, to the Sheriff, and the Sheriff, not being a Sheriff-substitute resident within the district, may either approve or disapprove of such resolution.

Resolution of L. A. to be published in district.

Right of appeal to Sheriff by any person interested.

Finding of Sheriff if he disapproves of resolution of L. A.

If he disapproves thereof he may either find that no special drainage district should be formed, or may enlarge or limit the special district as defined in such resolution, or may find that such special drainage district or part thereof shall be combined as craved, or that such combination shall cease, or that such special drainage district or districts shall, as such, cease to exist.

The decision of the Sheriff shall be binding and shall be final except where it is pronounced by a Sheriff-substitute, in which case it may be appealed to the Sheriff.

(2) The order of the Sheriff shall determine all questions regarding payment of debt affecting any district or special drainage district, and the right to impose and the obligation to pay any assessment affected by his determination, and shall fix a date at which such determination shall take effect, and a copy of any such order shall be forthwith published as in the case of the resolution of the L. A., and be transmitted to the L. G. Board and to the County Council.

(3) Where a district committee is the Local Authority, notwithstanding the provisions of s. 17 (2), (*c*) of the Local Government (Scotland) Act, 1889, it shall not be competent to appeal to the County Council against any resolution of the district committee under this section.

(4) Where a special drainage district has been formed, or may hereafter

be formed under this Act, the district committee of the district in which such special drainage district is or may be situated, or the County Council where a county is not divided into districts, shall in their discretion have power to provide for the drainage of the highways and footpaths under their management and control within such special drainage district, or to pay or contribute out of the assessments raised under the Roads and Bridges (Scotland) Act, 1878, a proportion of the cost of providing and maintaining sewers sufficient for the drainage of such highways and footpaths.

(5) Nothing contained in this Act shall prejudice the provisions of subsections 1 and 2 of s. 81 of the Local Government (Scotland) Act, 1889, as amended by s. 44 of the Local Government (Scotland) Act, 1894 (*q.v.* p. 323).

Section 123. The making of works of distribution and service for the supply of sewage to lands for agricultural purposes shall be deemed an improvement of land authorised by the Improvement of Land Act, 1864, and the provisions of that Act shall apply accordingly.

Works for distribution of sewage on land to be deemed a land improvement.

Section 139. Makes it lawful for a L. A. to borrow moneys for sewers and utilisation of sewage under prescribed conditions.

Note.—A district committee is not, however, empowered to borrow. This power can only be exercised in landward districts by the County Council, with consent of the joint standing committee (*vide* Local Government (Scotland) Act, 1889, s. 67).

II. Burgh Police (Scotland) Act, 1892; Sections 215–237.

Section 215. All sewers and drains within a burgh, whether made before or after the passing of this Act (except private branch-drains, drains made and used for draining, preserving, or improving land, and sewers made under any local or private Act of Parliament) shall vest in and belong to and be entirely under the management and control of the Commissioners.

Sewers and drains to be vested in Burgh Commissioners.

Section 216. Enables Commissioners to purchase the rights, privileges, powers, and authorities vested in any person for making sewers not hereby vested in the Commissioners or to contract for the use of such, or to purchase such sewers, with or without buildings, works, materials, and things belonging thereto; and to any person to whom such rights, etc., belong, to sell and dispose of the same to the Commissioners, or otherwise to contract with the Commissioners. After any such sale, the purchase-money shall be settled and applied to the same uses and purposes to which the property purchased may have been subject at time of such sale, and the property so sold shall vest in and belong to the Commissioners, any law to the contrary notwithstanding; provided that the seller shall have the right to use the same or other sewer substituted in lieu thereof in as ample a manner as before the purchase.

Power to purchase, etc., certain sewers.

Section 217. Nothing in this Act shall be construed to authorise the Commissioners, contrary to any private right, to use, injure, or interfere with any sewers or other works already made or used for the purpose of draining, preserving, or improving land under any local or private Act of Parliament, or for the purpose of irrigating lands, or to use, injure, or interfere with any water-course, stream, river, dock, basin, wharf, quay, or towing-path in which the owner or occupier of any lands, mills, mines, or machinery, or the proprietors of any canal or navigation shall have right or interest, without consent in writing of the person legally entitled to grant the same; and nothing in the Act shall prejudice or affect the rights, privileges, powers, or authorities given or reserved to any person under any local or private Act of Parliament for the drainage, etc., of land, or for or in respect of any mills, mines, machinery, canal, or navigation, as last aforesaid.

Private sewers or water-courses, etc., not to be used without consent.

Section 218. Commissioners shall form the whole Burgh into one drainage district, subject to the following exceptions and provisions:—

(1) Where at the application of this Act separate districts exist, the same shall be maintained, unless and until they are altered in the manner hereinafter provided;

Drainage districts only to be formed after approval by Sheriff.

(2) Commissioners may divide the Burgh into separate drainage districts with approval of the Sheriff, if special and exceptional circumstances exist to his satisfaction making it expedient to do so ;

(3) Commissioners may unite or alter existing separate districts with approval of the Sheriff ;

(4) Any alteration of districts existing at the application of this Act shall be subject to such conditions as the Sheriff may impose ;

(5) Commissioners shall cause their surveyor to define and describe the several drainage districts, and any alterations made thereon from time to time, upon a plan of the Burgh to be made as hereinafter provided for.

Power to Commissioners to construct sewers where none exist, making compensation to owners of property.

Section 219. Commissioners shall from time to time, subject to the restrictions herein contained as to notice to be given, and plans and estimates to be prepared, cause to be made, under the streets or elsewhere, such main and other sewers as shall be necessary for the effectual draining of the burgh, and all such other works as shall be necessary for cleansing such sewers, and if needful may carry such sewers through and across all underground cellars and vaults under any such streets, doing as little damage as may be and making full compensation for any damage done ; and may carry the same into or through any enclosed or other lands, making compensation to owners, and occupiers thereof ; and they may cause the refuse of such sewers to be conveyed by a proper channel to the most convenient site for its collection and sale for agricultural or other purposes, as may be deemed most expedient, but so that the same shall in no case become a nuisance ; Provided always, that if in making any such main and other sewers, or in repairing, constructing, or enlarging the same or existing drains or sewers, the contents at present carried in any existing outlet shall be diverted to the prejudice of any actual existing legal right, the Commissioners shall be bound to make compensation therefor, such compensation to be settled as compensation for land to be taken under the provisions of the Lands Clauses Acts.

Commissioners to give notice of making new sewers, or of altering or abandoning existing sewers.

Section 220. At least 28 days before making any new sewer where none before existed or altering the course or level of or stopping or abandoning a sewer, the Commissioners shall give notice of their intention, by posting a notice in a conspicuous place at the end of every such street through or in which the work is to be undertaken, which notice shall set forth the names of streets and places through or near which the new sewer shall pass or the existing sewer shall be altered or stopped up, and also, the places of beginning and the end thereof, shall refer to the plans of such intended work, and shall specify a place where plans may be seen, and a time when and a place where all persons interested in the intended work may be heard thereupon. (*Cf.* section 25 of Act of 1903, p. 323.)

Commissioners to meet and hear objectors.

Section 221. Commissioners shall meet at time and place mentioned in said notice to consider, in the presence of their surveyor, any objections made against any such intended work, and all persons interested in or likely to be aggrieved by such intended work shall be entitled to be heard at such meeting. Thereupon, the Commissioners may at their discretion abandon or make such alterations in the said intended work as they judge fit : and no such work to which any objection has been made at such meeting shall be executed unless the burgh surveyor shall certify that the work ought to be executed, nor shall such work be begun until the end of 7 days after an order for its execution has been duly made by the Commissioners and entered in their books.

Where works for sewage are provided, streams are not to be polluted.

Section 222. Whenever the Commissioners shall have caused pipes or other works to be laid in or along any river, burn, or water-course within the burgh for the purpose of intercepting and conveying away the sewage which would otherwise flow into and pollute the same, it shall be unlawful for any person to introduce into any part of such river, burn, or water-course, along which such pipes are laid, any sewage or other offensive matter or thing from any source :

and the Commissioners are hereby authorised to allow junctions to be made with such pipes or works for drainage of any lands and premises which would naturally fall into such river, etc., on such terms as they may arrange with persons requiring such drainage, and failing arrangement, on such terms as may be fixed by the Sheriff, who is hereby required to hear and determine such questions. Infringement of the provisions of this section to be followed by penalties after conviction.

Section 223. Any person who shall lay or throw, or cause or procure to be laid or thrown, any rubbish, earth, ashes, corks, straw, soil, filth, or refuse, or any other matter, whether offensive or not, into the channel or on the banks or sides of any river, etc., flowing through or on the boundary of a burgh shall upon conviction of the offence be liable to a penalty.

An offence to throw rubbish, etc., into streams.

Section 224. Gives power to Commissioners at any time and in any way to alter sewers, or to demolish and discontinue any sewer which appears to them to have become useless, provided that the same is done without creating a nuisance.

Commissioners may alter sewers from time to time.

Section 225. If any person, by reason of any alteration or discontinuance of any sewer or of other proceeding of the Commissioners, be deprived of the use of any sewer or drain which such person was theretofore lawfully entitled to use, the Commissioners shall provide some other drain or sewer equally effectual for the purpose ; and if the Commissioners do not, within 7 days after notice in writing has been served upon them, begin and diligently proceed to restore the existing drain or to provide a new sewer or drain, they shall forfeit to the person aggrieved a sum not exceeding 40s. for every day after expiration of such 7 days during which such person is deprived of the use of the drain or sewer to which he was entitled and is not provided with such other drain or sewer.

Commissioners not to destroy existing drains or sewers without providing others.

Section 226. Before entering into any contract for executing any such work as aforesaid, Commissioners shall procure from their surveyor an estimate of the probable expense of constructing the same in a substantial manner and of the yearly cost of maintenance, and the surveyor shall at the same time report as to the most advantageous mode of doing the same.

Commissioners to obtain estimate of cost before proceeding with work.

Section 227. Every person, not employed or authorised for that purpose by the Commissioners, who shall make any drain from lands or premises into any of the sewers vested in the Commissioners shall be liable to a penalty ; and the Commissioners may cause such drain to be remade as they may think fit, the expense incurred thereby to be paid by the owner of the lands or premises and that over and above a reasonable sum of money for the use of the sewers.

Penalty for making unauthorised Drains.

Section 228. No building shall be erected over any sewer belonging to the Commissioners, and no vault, arch, or cellar shall be made under the carriage-way of any street, public or private, without the consent of the Commissioners in writing. If such consent be obtained, all such vaults, arches, etc., shall be substantially made and so as not to interfere or communicate with any sewer belonging to the Commissioners. If after this Act comes into force any such building be erected, or any arch, vault, or cellar be made, contrary to the provisions of this section, the Commissioners may demolish or fill up the same at the expense of the person erecting such building or making such arch, vault, or cellar.

Vaults and cellars under streets not to be made without consent of Commissioners.

Section 229. All sewers and drains, whether public or private, shall be trapped and ventilated by the Commissioners or other persons to whom they severally belong.

Sewers and Drains to be Trapped.

Section 230. Commissioners shall have power for the purpose of providing ventilation for existing sewers or drains, or for sewers or drains hereafter constructed, to acquire by agreement lands and premises, and to construct ventilating shafts, furnaces, and other means of ventilating the sewers and other works which may be found necessary, and if necessary to carry them upon, into, or through any enclosed or other private premises, the Commissioners to have the same powers and be liable to the like restrictions in so doing as are by this Act provided for constructing sewers.

Commissioners empowered to ventilate sewers and sewage-works.

Commissioners may arrange with owner or occupier of any manufactory to fix arrangements for ventilating their sewers.

Section 231. Commissioners may arrange with the owners or occupiers of any manufactory, gaswork, or brewery, having furnaces and chimney-shafts so situated as to be available for the ventilation of adjacent sewers and drains, for such ventilation, or of other suitable premises, and to lay and fix such ventilators, pipes, or shafts, into, on, or against such buildings or premises as to them seem proper, and as may be agreed upon, making compensation to the owners thereof.

Costs and charges.

Section 232. Costs and expenses in carrying out provisions of foregoing section to be a charge against the general sewer-rate or any special sewer-rate as Commissioners may judge fit.

Distillers and others to construct reservoirs to deposit refuse.

Section 233. Any owner or occupier of distilleries, manufactories, or other works who causes or permits any refuse, refuse-water, steam, or other substance fitted to interrupt the free passage of a sewer or to be otherwise injurious thereto or to be injurious to the health of persons living in the vicinity, to enter a public sewer, river, or inland loch, or public reservoir or dock from any such works shall be guilty of an offence, and on conviction shall be liable to penalties for the offence and for daily continuance and for expenses for taking out of the sewer any refuse or substance that may have entered it from his works.

Such owners and occupiers shall construct pools or reservoirs as near their works as possible, for receiving and depositing such refuse and other substances.

If it shall be impracticable, in the judgment of the Commissioners, to render such refuse or other substances inoffensive or innocuous, or to prevent the same from interrupting the free passage of the sewer or otherwise injuring the same, it shall be lawful for the Commissioners to prohibit and interdict such owner or occupier from permitting the same to run into such sewer from his works aforesaid ; and while such prohibition and interdict are in force, or if and so long as the owner or occupier of such works makes no use of the sewers in consequence of having before this Act came into force made separate arrangements for the drainage of the works, such owner or occupier shall be entitled to be exempted from the sewer-rates to the extent of 75 per cent. thereof applicable to the whole building or such part or parts thereof as by such prohibition or previous separate arrangement are deprived directly or indirectly of any benefit from the sewer ; provided that the sewer-rates payable in respect of the other parts of such works shall still remain payable ; and if the prohibition and interdict be at any time by the Commissioners withdrawn, or the owner or occupier having previous separate arrangements shall begin to use the sewers, then the exemption shall cease, and if the owner or occupier is dissatisfied with the decision of the Commissioners as to the question of practicability aforesaid, or as to the part of the works for which such exemption ought to be made, it shall be lawful for such owner or occupier to appeal to the Sheriff in manner after provided.

Sewers may be used by owners and occupiers of land or premises beyond limits of Burgh.

Section 234. Any person being the owner or occupier of any lands or premises beyond the Burgh, or not included in the drainage thereof, and in respect of which he would not be liable for payment of rates authorised to be levied under this Act or the Local Authority of any district under the Public Health Acts, may, with the consent of the Commissioners in writing, upon payment to them of a reasonable sum of money to be agreed upon between them, at his or their own expense, and under the superintendence of the surveyor of the Commissioners, cause to branch into and to communicate with any of the sewers belonging to the Commissioners any sewer or drain in respect of the said lands or premises or district which may be lawfully made therefrom of such size and in such form of communication as the Commissioners approve ; but nothing in this Act shall affect any right theretofore acquired by such owner or occupier to use any sewer or drain belonging to the Commissioners.

Drains may be made to discharge below high-water mark.

Section 235. If Commissioners shall consider it necessary for public health that any drain should discharge itself below high-water mark they shall be entitled, with consent of the Board of Trade, to construct the necessary works under regulations provided in regard to works authorised by this Act.

Section 236. Empowers Commissioners to borrow money for the purpose of making, purchasing, enlarging, ventilating, reconstructing, and maintaining sewers.

Powers to Commissioners to borrow money for construction of sewers.

Section 237. It shall be lawful for any person whose property may be taken or injuriously affected by the making, altering, and maintaining of sewers, or who may think himself aggrieved, to appeal to the Sheriff.

III. Burgh Police (Scotland) Act, 1903. Part I.

Section 25. Where the Town Council has resolved to abandon any sewer vested in them and used as part of the sewage-system of the burgh and to substitute a new sewer in its place, they shall either connect with the new sewer the branch-drains connected with the abandoned sewer, making such alterations or repairs thereon as may be necessary, or construct or lay from the new sewer new covered branch-drains of such materials, of such size, at such level, and with such fall as may be necessary for drainage of the houses or buildings previously drained by means of the abandoned sewer. All expenses of repair, etc., shall be recoverable from the owners of houses or buildings. (*Cf.* sections 220 and 225 of Act of 1892.)

IV. Burgh Sewerage, Drainage, and Water-Supply (Scotland) Act, 1901.

Section 2. In any burgh, or in any special or separate drainage district formed therein under any Act, the expenses incurred either before or after the passing of this Act for sewerage and drainage or water-supply, as the case may be, within the same, or for the purposes thereof, together with the sums necessary for the repayment of capital and interest of any money borrowed therefor either before or after the passing of this Act, shall be paid out of a sewer-assessment or water-assessment as the case may be, which the Town Council of the burgh shall raise and levy on and within such burgh or (in the case of the sewer-assessment) within such special or separate district ;

Provided that where a special or separate drainage district has been formed under the provisions of any Act, and drainage-works have been executed and maintained therein, the lands and heritages situated within such special or separate district shall not be liable to assessment for the expense of sewerage and drainage works in other parts of the burgh.

The sewer-assessment and the water-assessment together shall not in any burgh or special or separate drainage district exceed the rate of four shillings in the pound ; Provided that if the produce of a rate of four shillings in the pound in any burgh or special or separate drainage district shall not be sufficient to meet the expenditure, it shall be lawful to increase such rate to such extent as may be approved by the Local Government Board.

Section 3. All special or separate drainage districts that may have been formed in any burgh under any Public Health Act shall, subject to the provisions of this Act, be deemed to be drainage districts under the principal Act.

Section 5. The powers and duties of the Town Council of any burgh, as the Authority under the principal Act, with reference to sewerage and drainage or water-supply shall extend to the whole area of the burgh as existing for the purposes of the Public Health (Scotland) Act, 1897, and the Town Council, as the Authority under the principal Act, in addition to the powers conferred upon them by that Act, shall, with reference to sewerage and drainage or water-supply within such area, have the same rights, powers, and privileges as are conferred by the Public Health (Scotland) Act, 1897, upon Local Authorities under that Act in districts other than burghs, with the exception of the rights, etc., conferred by sections 122 and 131 of the last-mentioned Act, to which sections the present section shall not apply.

V. Local Government (Scotland) Acts, 1889, and 1896.

The Local Government Act, 1889, section 81, sub-sections 1 and 2, as amended by the Local Government Act, 1894, section 44, sub-section 9, provides as follows :—

Section 81. With respect to special drainage districts or special water-supply districts the following provisions shall have effect :—

(1) Where a special drainage district or special water-supply district has been formed in any parish under the Public Health Acts, the District Committee may, subject to regulations to be from time to time made with the consent of the County Council, appoint a sub-committee for the management and maintenance of the drainage or water-supply works, and such sub-committee shall in whole or in part consist of parish councillors of the parish or parishes in which the special district is situated, whether members of the District Committee or not;

(2) Where a special drainage district or special water-supply district is partly within a county and partly within a burgh or police burgh, the sub-committee appointed under the immediately preceding subsection, and such number of the Town Council or Police Commissioners (as the case may be) of such burgh or police burgh as failing agreement the Secretary for Scotland may determine having regard to all the circumstances of the case, shall be charged with the management and maintenance of the drainage or water-supply works within such special district, and the determination of the Secretary for Scotland may provide for the regulation of the proceedings and for the allocation and payment of the expenses incurred under this sub-section.

Section 44 (9) of the Act of 1894 provides that the number of a subcommittee appointed under the said section may, failing agreement between a District Committee and a County Council and a Town Council or Commissioners of a police burgh, be determined by the Secretary for Scotland.

(*Cf.* sections 3 and 5 of the Burgh Sewerage, Drainage, and Water-Supply (Scotland) Act, 1901, p. 323.)

II. Law concerning Drains, Ditches, and House-Drainage.

I. Public Health (Scotland) Act, 1897.

For the purposes of this Act, according to—

Drain may be a nuisance.

Section 16, sub-section 2. Any *drain* in such a state or so situated as to be a nuisance or injurious or dangerous to health; and

Schoolhouse or factory with foul-smelling drain to be deemed a nuisance.

Section 16, sub-section 8. Any schoolhouse or any factory, not being a factory subject to the provisions of the Factory and Workshop Act, which is not kept in a cleanly state and free from effluvia arising from any drain, shall be deemed to be nuisances liable to be dealt with summarily in manner provided by the Act.

Local Authority and power of entry to premises and to open drains.

Section 18. Enacts that if the Local Authority, or medical officer, or sanitary inspector have reasonable grounds for believing that nuisance exists in any premises, such Local Authority, medical officer, or sanitary inspector may demand admission for themselves, the chief constable or superintendent of police or any other person whom the Local Authority may desire, to enter and inspect such premises, and, if necessary, to open up the ground of such premises, or for any or all of them to inspect the same at any hour between 9 A.M. and 6 P.M., or at any hour when the operations suspected to cause the nuisance are believed to be in progress or are usually carried on; and may cause the ground or surface to be opened, *and the drains to be tested*, or such other work to be done as may be necessary for an effectual examination of the said premises; provided always, that if no nuisance be found to exist, the Local Authority shall restore the premises at their own expense. If admission be refused, the Local Authority, or medical officer, or sanitary inspector may apply to the Sheriff or to any magistrate or justice of the peace having jurisdiction, stating on oath such belief; and such Sheriff, etc., may, after intimation to the owner or occupier, or person in charge of the premises, by order in writing require such person to admit the Local Authority and others aforesaid. If such occupier, etc., fail to obey such order, he shall, on conviction, be liable to a penalty; and on being satisfied of such failure or refusal, the Sheriff, etc., may grant warrant to such Local Authority, officers, or persons for immediate forcible entry into the premises. If no occupier or person can be discovered, or if no person be found on the premises to give or refuse admission, the Local Authority or their officers may enter the premises without any order or warrant, and forcibly if need be. Provided that if no nuisance be found to exist, the Local Authority shall restore the premises at their own expense.

Any order by a Sheriff, magistrate, or justice for admission under this section shall remain in force until nuisance is removed, or the work for which the entry was necessary has been done.

Foul ditches, etc., may be replaced by sewers.

Section 28. Whenever any water-course, ditch, gutter, or *drain* along the side of any street, or between or parallel to rows of dwelling-houses, shall be used or partly used for the conveyance of any water, sewage, or other liquid or matter from any premises, and cannot in the opinion of the Local Authority be rendered free from foulness or offensive smell without the laying down of a sewer or some other structure, such Local Authority shall and they are hereby required to lay down such sewer or other structure within the limits of their district, or subject to the approval of the L.G. Board, where necessary for the purpose of outfall or distribution of sewage, without their district, and to keep the same in good and serviceable repair; and such Local Authority are authorised, and empowered to assess the owners of all the premises from which then or thereafter other than pure water flows, falls, or is carried into the said sewer or other structure.

Provision for obtaining order for cleansing offensive ditches lying near to or forming boundaries of districts.

Section 41. Where any water-course or open ditch lying near to or forming the boundary between the district of any Local Authority and any adjoining district is foul and offensive, so as injuriously or dangerously to affect the district of such Local Authority, any Sheriff having jurisdiction *in such adjoining district* may, on the application of such Local Authority, summon the Local Authority of such adjoining district to appear to show cause why an order should not be made for cleansing such water-course or open ditch, and for executing such permanent or other structural works as may appear to such Sheriff to be necessary; and such Sheriff, after hearing the parties, or *ex parte* in case of the default of any of them to appear, may make such order with reference to the execution of the works and the persons by whom the works shall be executed, and by whom and in what proportions the costs of the same shall be paid, and also as to the amount thereof, and the time and mode of payment, as to such Sheriff may seem reasonable.

Section 181. The Local Authority of any district other than a burgh may, subject to approval of the County Council, make bye-laws for the whole or any part of their district for regulating the building or rebuilding of houses or buildings, or the use for human habitation of any building not previously so used, or any alteration in the mode of occupancy of any existing house in such a manner as will increase the number of separate houses in respect *inter alia* to the following matters:—

(1) The drainage of the subsoil of sites for and the prevention of dampness in houses intended for human habitation;

(2) The construction and arrangement of the drainage of houses and buildings and of soil-pipes and waste-pipes, and the construction and position of water-closets, earth-closets, privies, ash-pits, cesspools, dungsteads, slop-sinks, and rain-water pipes and rhones;

(3) The intimation previous to the commencement by the owner or person laying out the work to the Local Authority of the date of commencement, and for the due inspection in respect of the matters in this section mentioned of houses and buildings in process of erection or alteration, *and the examination of the drains thereof*, and for the pulling down, alteration, or amendment of any work which has been carried out in contravention of the bye-laws.

II. Burgh Police (Scotland) Act, 1892; Sections 238–256.

Commissioners may construct drains from houses, charging owners with the expense.

Section 238. If any house or building and its pertinents be at any time not drained by a sufficient drain or pipe communicating with some sewer or with the sea to the satisfaction of the Commissioners, and if there be means of drainage within 100 yards of any part of such house or building, the Commissioners shall construct such a suitable drain as they think necessary, and the expense shall be recoverable from the owner, in addition to any charge for the use of the sewers.

No house to be hereafter built without drains being constructed.

Section 239. No house or building shall be built upon a lower level than will allow drainage of the wash and refuse thereof to fall into some sewer of the Commissioners either existing or to be constructed by the Commissioners, if there be means of drainage within 100 yards ; or if there be no means of drainage within such distance of intended site of building, then such drain shall be made so as to lead into a covered cesspool or other place as the Commissioners shall direct, which shall be constructed and kept in complete repair to the satisfaction of Commissioners so as effectually to prevent leakage or effluvium therefrom, until a new sewer shall have been laid down.

When house is re-built the level to be sufficient to allow a drain to be constructed.

Section 240. Whenever any house is rebuilt, the level of the cellar or other lowest floor of such house shall be raised sufficiently to allow of the construction of such drain as laid down in previous section. Whenever any house is taken down to or below the ceiling of the ground or street floor, for the purpose of being built up again, such building shall be deemed a rebuilding within the meaning of this Act.

Ventilation and trapping of house-drainage.

Section 241. Proper ventilation shall, if required by the Commissioners, be provided in the drainage of every house or building by special pipe or shaft or by such other method as they shall direct. All other inlets to drains shall be properly trapped.

Drains and cesspools to be kept in good order by owners.

Section 242. All branch-drains, within and without the premises to which they belong, and all cesspools or reservoirs, shall be under the survey and control of the Commissioners, and shall be kept in proper order at the cost and charge of the owner of the premises.

Inspection of drains and cesspools.

Section 243. The surveyor of the Commissioners may, and when requested by the M.O.H. or the S.I. shall, inspect any drain or cesspool or reservoir, and for that purpose, at all reasonable times in the daytime, after 24 hours' notice in writing to the occupier of the premises to which such drain, etc., is attached, may enter with such assistants as are necessary, and cause the ground to be opened where he thinks fit, doing as little damage as may be. If drain, etc., be found in good order, he shall cause the ground to be closed and made good as soon as may be, and in that case expense shall be defrayed by Commissioners. All branch-drains which have been opened for repairs, or for any purpose, shall not be covered up before they have been inspected and tested by the Commissioners or their surveyors, such inspection and testing to be made within 24 hours after notice has been given by the owner. Contravention of the foregoing to be followed by a penalty, and the Commissioners may further re-open the drain and test it, all at the owner's expense.

Penalty on persons making or altering drains, etc., contrary to orders of Commissioners.

Section 244. If any such drain or cesspool or reservoir be on inspection found to have been constructed after this Act came into force contrary to the directions and regulations of the Commissioners or contrary to the Act, or if any person, without consent of the Commissioners, shall construct, rebuild, or unstop any drain, etc., every such person shall be liable to a penalty ; and the Commissioners may cause such alterations in the drain, etc., as they think fit.

Soil-Pipes and Water-Closets and Ash-pits, etc.

Water and sinks and water-closets may be ordered in houses by Commissioners.

Section 246. Within one month after written notice by the Commissioners, the owner of every house or part of a house occupied by a separate family, into which water has not been already introduced, shall, subject to any bye-laws made by the Commissioners, introduce water thereto, and shall fit up in some window, recess, or other well-lighted and ventilated place, a sink sufficient to carry off the whole foul water ; and after a like notice, every owner shall provide for such house or part of a house occupied by a separate family, wherever practicable, a sufficient water-closet ; Provided always that if the Commissioners are of opinion that it is not advisable to introduce water-closets into each house, they may, after a like notice, require the owners to construct on each flat, or in some adjacent convenient place, a sufficient number of water-closets for the separate use of each sex of the inmates and occupiers of the said tenements ; Provided further, that this enactment shall not be enforced where, from insufficient pressure of water or absence of drains, or from other cause, such works shall be impracticable or inexpedient.

Owners of flats of houses to have supply-pipe from main water-pipe.

Section 247. It shall be lawful for owners of any one or more floors or storeys of any house or building to have a supply-pipe from any water-pipe in the street brought up the common staircase, or along the back or side-wall of the tenement on the outside, and either passing underground through the sunken storey or lowest flat, or, where practicable, through any common entry. Authority shall be first obtained from the magistrate to lay and put up the pipe, the expense to be borne by the owner. Permission to join the supply-pipe to any main-pipe to be also obtained from any water-company.

Soil-pipes may be carried through houses on different flats.

Section 248. Where there are two or more houses in any tenement, the owner and occupier of each house shall permit soil-pipes, if unavoidably necessary, to be carried through the same ; and the owner and occupier of the lowest storey shall permit such soil-pipes, if necessary, to be carried through or under the same ; and all such owners and occupiers shall at all reasonable times afford access to all such houses for construction of works and repairs thereon, at the sight of the burgh surveyor.

Penalty for introducing ashes into soil-pipe.

Section 249. Any person who shall put into a soil-pipe or cesspool any ashes or any matter calculated to choke the same shall be liable to a penalty and to expense of repair.

Owners of flats of houses may erect waste-pipes to communicate with drains.

Section 250. In all streets and other places where common sewers are or may be constructed, it shall be lawful for any owner of one or more floors or storeys of any houses divided into separate floors or storeys (on obtaining authority for the purpose from the magistrate on report and recommendation of the surveyor or other skilled person) to erect a waste or foul water-pipe or soil-pipe with trap in or upon the common staircase, or upon any wall of the tenement outside, to communicate with any drain underground leading into a common sewer where there is such a drain, and with power to make such drain if none such already exist ; Provided always, that the sanction of the Commissioners shall be obtained before connecting such drain with any common sewer in the street.

Construction of water-closets, earth-closets and privies.

Section 251. The situation, dimensions, materials, and construction of every water-closet or earth-closet and privy shall be subject to the approval of the Commissioners, and every such convenience hereafter to be constructed shall be placed in such a position that one of its sides shall be an external wall, with a window containing an area of at least six superficial feet, one half of which shall be made to open, and the cistern which supplies the w. c. (except the service-pipe connected therewith) shall have no communication with the w. c. ; Provided that in the case of such conveniences erected prior to the passing of the Act it shall be optional for the Commissioners to exact the foregoing provisions.

Construction of cesspools.

Section 252. A cesspool shall not be allowed for any house or building except when unavoidable, in which event it shall be constructed in such situation and in such manner and under such conditions as the Commissioners shall direct. In every case it shall be made water-tight, shall be arched or otherwise covered over, and shall be ventilated by a pipe carried up from it as directed by the Commissioners.

Construction of ashpits, etc., and use of same.

Section 253. The situation, dimensions, drainage, materials, mode of access, and construction of every ash-pit shall be subject to the approval of the Commissioners, and shall be of sufficient size to contain the ashes and dry refuse likely to accumulate between such visits of the scavengers as the Commissioners may prescribe ; Provided that if any person, not being the owner or occupier of the house or premises to which any ash-pit belongs or is attached, shall deposit any matter therein, such person shall be guilty of an offence.

Owners to remove cesspools, etc., after notice.

Section 254. The owner of any privy, ash-pit, cesspool, or midden, extending wholly or partially under or close to any room built before or after this Act comes into operation, shall, within one month after notice to that effect by the Commissioners, remove or cleanse and build up the same.

Power to enforce conversion of privies into water-closets.

Section 255. Where any privy, ash-pit, or cesspool is certified by the M.O.H. to be prejudicial to health, of defective construction, or without drainage, or in a bad state of repair, or to be so situate that the removal of filth or refuse therefrom is prejudicial to health, the Commissioners, by written notice, may require the owner, within a reasonable time specified in the notice, to reconstruct, or alter, or repair the same, or to convert the privy into a water-closet or earth-closet, to the satisfaction of the Commissioners; and the Commissioners may, if they think fit, order the removal of such privy, ash-pit, or cesspool.

Water-closets or earth-closets and urinals to be attached to public-houses, etc.

Section 256. The Commissioners may order the owner or occupier of any inn, public-house, beerhouse, eating-house, cook-shop, or other place of public entertainment or amusement, built before or after this Act, to provide within such time as the Commissioners think fit, and thenceforward to maintain upon or adjoining his premises, one or more water-closets, earth-closets, and urinals, to the satisfaction of the Commissioners. Failure to comply involves a penalty for the offence and for daily continuance. The Commissioners may order the owner and occupier of any premises to remove any such convenience belonging thereto, where it appears to them so situated or so constructed as to be a nuisance or offensive to public decency, or otherwise objectionable; and all such urinals shall be cleansed once in 24 hours by the occupier of the house or place to which they belong, to the satisfaction of the Commissioners, a penalty attaching to any default thereof. (*Cf.* section 44, Public Health Acts Amendment Act, 1907, for England.)

Cleansing and Scavenging and Removal of Refuse.

Public Health (Scotland) Act, 1897.

Accumulations or deposits to be deemed a nuisance.

Section 16 (5) declares that any accumulation or deposit, including any deposit of mineral refuse, which is a nuisance or injurious, or dangerous to health, or any deposit of offensive matter, refuse, or offal, or manure (other than farmyard manure or manure from byres or stables, or spent hops from breweries), within 50 yards of any public road wherever situated, or any offensive matter, refuse, or offal, or manure other than aforesaid contained in uncovered trucks or waggons standing or being at any station or siding or elsewhere on a railway or in canal-boats so as to be a nuisance or injurious or dangerous to health—shall be deemed to be a nuisance under this Act; but a penalty shall not be imposed on any person in respect of any accumulation or deposit necessary for the effectual carrying on of any business, trade, or manufacture, if it be proved to the satisfaction of the Court that such accumulation or deposit has not been kept longer than is necessary for the purposes of the business, and that the best available means have been taken for preventing injury or danger thereby to the public health.

Removal of house and street refuse to be an offensive business.

Section 37. (1) Enacts that the removal of house-refuse and street-refuse by a Local Authority when collected and deposited by such Authority or by any person authorised by such Authority, shall be deemed to be a business (offensive) carried on by that Authority within the meaning of this Act, and a complaint or proceedings in relation thereto may be made or taken by the County Council of the district, other than a burgh, where such business is carried on, or in the case of any district, by any person authorised by the L. G. Board in like manner as if such County Council or such person were a Local Authority.

(2) Any premises used by a Local Authority or by any person authorised by them, for the treatment or disposal of any street-refuse or house-refuse, as distinct from the removal thereof, which are a nuisance or injurious or dangerous to health, shall be a nuisance under this Act, and for the purpose of the application thereto of the provisions of this Act relating to such nuisances the County Council, in the case of a district other than a burgh, and any person authorised by the L. G. Board shall be deemed a Local Authority.

Section 40. Empowers a Local Authority to cause owner or occupier of a filthy house to cleanse and purify the same.

This section has been taken from Section 46 of the Public Health Act for England, 1875 (see p. 340), but with this difference, that in English law the Local Authority can only take action on the certificate of a M. O. H. or of two medical practitioners.

Notice may be given in Special Scavenging Districts for periodical removal of manure from mews, stables, etc.

Section 42. Notice may be given by any Local Authority (by public announcement in the district or otherwise) for the periodical removal of manure or other refuse-matter from mews, stables, or other premises, except cattle-courts, *in any special scavenging district,* and where any such notice has been given and when any person fails so to comply, such person shall be liable to a penalty for the offence and to a further penalty for daily continuance. If it appears to the sanitary inspector that any such accumulation of manure, etc., ought to be removed, he shall give notice to the owner to remove the same, and if such notice is not complied with within 48 hours from the service thereof, the manure, etc., shall be vested in and shall be sold and disposed of by the Local Authority, and the proceeds thereof shall be applied in payment of the expenses incurred in the removal; the surplus (if any) shall on demand be paid to the owner of the matter removed, and if the proceeds are less than the costs of removal, the balance may be recovered summarily from the owner; whom failing, from the occupier of the premises by the Local Authority.

Special Scavenging Districts.

Local Government (Scotland) Act, 1894.

Requisition for formation of Special Scavenging District.

Section 44. (1) Enacts that it shall be lawful in a county for a Parish Council or for any two or more Parish Councils or for not fewer than *ten* parish electors of any landward parish or of the landward part of any parish partly landward and partly burghal, to make a requisition in writing to the district committee divided into districts, calling upon them to form such parish or parishes or landward part of a parish or any portion or portions of them into a special district for the following purpose—viz.

The scavenging of, and the removal of dust, ashes, and other refuse from the streets, roads, footpaths, lands and premises in such special district, and the adoption for such purposes by the district committee of the County Council, or the County Council, as the case may be, of the provisions contained in sections 107 to 127, and sections 253 to 255 inclusive, of the Burgh Police (Scotland) Act, 1892, or any one or more of them.

(2) Upon such requisition being received, the district committee or the County Council, as the case may be, shall be bound to meet after 21 clear days' notice, shall consider the propriety of forming such parish, etc., into a special district, and shall by resolution either approve or disapprove of the formation of such special district (which shall in no case include a police burgh or any portion thereof) for the purposes stated in the requisition, and if they approve, shall define the boundaries of such special district and specify which of the provisions of the Burgh Police (Scotland) Act, 1892, are to be adopted therein. Such resolution shall be final, subject to the provisions of sub-section 3 of this section, and in the event of the district committee or the County Council, as the case may be, disapproving of the formation of a special district as proposed, it shall not be competent to make requisition to the same effect until after the expiration of 12 months. A copy of every such resolution shall be forthwith published in one or more newspapers circulating in the district, and be transmitted to the L. G. Board and to the County Council.

(3) Where the proposed special district is co-extensive with or comprises the whole or part of the area of any special drainage or water-supply district formed under the Public Health Acts, the consent of the County Council shall be required to any resolution approving of the formation of a special district under this section, and in giving or refusing such consent the County Council shall take into consideration the whole circumstances of the case, including the amount of the rates levied for the time being under the Public Health Acts and the

Principal Act within the proposed special district, and the County Council may consent to the resolution either with or without modifications.

(4) On the adoption by a district committee or County Council, as the case may be, of any of the fore-mentioned provisions, such provisions shall have effect within or in relation to the special district, subject to the provisions of the fourth schedule to this Act annexed.

The Public Health (Scotland) Act, 1897.

Section 38. Enacts that with respect to the formation of special districts for scavenging, and other purposes under section 44 of the Local Government (Scotland) Act, 1894—

It shall be competent for any person interested to appeal to the Sheriff against any resolution of a district committee or County Council as the case may be, under sub-section 2 of section 44, and all the provisions of sub-section 1 of section 122 of this Act in regard to an appeal against a resolution of a Local Authority shall, with the necessary modifications, apply to an appeal against a resolution of a district committee or County Council as aforesaid ;

Provided that in cases to which sub-section 3 of the said section 44 of the Local Government (Scotland) Act, 1894, applies, an appeal to the Sheriff shall not be competent unless the resolution has been disposed of by the County Council in terms of that sub-section.

Where the boundaries of any burgh are extended so as to include the whole or part of any such special district, then the Town Council or Burgh Commissioners shall, as regards the whole of such special district, supersede the district committee or the County Council, as the case may be, in the administration of the Burgh Police (Scotland) Act, 1892, and other powers in regard to cleansing and scavenging, upon such terms as shall be agreed between the Town Council or Burgh Commissioners and the district committee or County Council, as the case may be, or, failing agreement, upon such terms as shall be fixed by the Sheriff, whose decision shall be final.

Burgh Police (Scotland) Act, 1892 ; Sections 107–127.

Dust, etc., collected to be vested in Commissioners.

Section 107. The dust, night-soil, dung, ashes, rubbish, filth and manure, including slaughter-house manure, whether such slaughter-house is or is not the property of the Commissioners (excepting always cattle-dung, mill-dust, and the ashes of any engine, furnace, oven, or stove, and the refuse of any breweries, tanworks, soap or chemical or other work), within the burgh, shall be vested in the Commissioners, who shall have power to sell and dispose of the same, and shall apply the money therefrom to the general purposes of this Act ;

And the Commissioners shall cause all streets and footpaths from time to time to be properly swept and cleansed, and all the dust, night-soil, rubbish, manure, etc., which is found on them, or in privies, sewers, cesspools, houses, or other premises, to be collected and removed at such convenient hours and times as they shall deem proper ;

And in all cases where there is insufficient access for a cart or wheel-barrow to the dungshed, ash-pit, or privy, the owner shall provide such access to the satisfaction of the Commissioners. Failing so to do, he shall pay the extra expenses of the removal of contents of same as the same shall be fixed by the Commissioners.

Commissioners may provide lands, etc., for deposit of soil and materials.

Section 108. The Commissioners may from time to time provide places convenient for the deposit, treatment, and disposal of the matters collected as aforesaid, and for the housing of horses, vehicles, and implements required for the purposes of this Act.

For any of such purposes the Commissioners may purchase or hire any lands or premises considered by them necessary, either within or beyond the boundaries of the burgh, and may acquire said lands and premises otherwise than by agreement under the Lands Clauses Acts with the authority of the L. G. Board, or they may erect any new buildings, machinery, appliances, and plant upon any lands so purchased or hired by them.

Removal of dust, ashes, and other refuse by Bin Service.

Section 109. The Commissioners may cause carts, having a covering proper to prevent the escape of the contents thereof, to pass through any street or district every morning between such hours as may be fixed by them, for the purpose of collecting and removing the material composing the burgh refuse from the lands and premises in and adjoining such street or district;

And may by public notice in one or more newspapers published or circulating, in the burgh, or by handbills posted in such street or district, require occupiers within and adjoining such street or district to cause all their material to be deposited in a suitable box to be approved of by the inspector of cleansing and placed daily on the outer side of the foot-pavement opposite the premises occupied by them, or at such other place near thereto as the said inspector shall appoint, not later than the time fixed;

And when such daily service is in operation in any such street or district, the Commissioners may direct any ash-pit in connection with premises therein or adjoining thereto to be shut up or removed; failure to comply with such notice to be followed by a penalty.

Commissioners may erect public conveniences and street refuse-boxes.

Section 110. Commissioners may erect or continue public water-closets or earth-closets, and latrines and urinals in suitable places, and may place movable or fixed boxes for temporary deposit of street-sweepings in any street in such situation as they may deem shall cause the least inconvenience or nuisance.

Streets to be watered.

Section 111. Commissioners shall, as often as they think necessary, cause the streets to be watered, and may contract for a supply of water from any water-company or person for that purpose; and if necessary, may place pipes or other necessary apparatus in any street for that purpose.

Appointment or employment of scavengers.

Section 112. Commissioners shall employ a sufficient number of scavengers, or contract with any person for sweeping, cleansing, or watering the streets, and for removing refuse, and for emptying privies, etc.; and every such contractor who fails to discharge his duty shall be liable to a penalty.

Penalty for obstructing scavengers.

Section 113. Enacts a penalty against any person who obstructs scavengers in the performance of their duty or who refuses to permit them to remove refuse.

Penalty on persons other than scavengers removing refuse.

Section 114. Makes it an offence for any person other than those employed by the Commissioners for that purpose to collect and remove refuse materials.

Sweeping and washing of common stairs, passages, etc.

Section 115. The occupiers of every house, flat, or storey having entrance by a common stair, shall cause the landing and the stair immediately below the flat possessed by them to be kept clean to the satisfaction of the sanitary inspector. If any flat be unoccupied, the occupiers of the flats above shall cause the landings and stairs below, leading to such empty flat, to be kept clean and washed downwards to the next house which is occupied; and if the top flat be unoccupied, then the stair leading thereto shall be kept clean by the occupier of the flat immediately below;

And any water-closet or other closet used in common, and any passage to an area or back green, or any ground used in common, shall be kept clean and washed by the occupants of the several houses in such tenement in weekly rotation;

And all areas and common passages leading to cellars shall be cleansed weekly by the occupiers of the cellars.

In cases where the common stair enters from or off a street above, the occupiers of every house, flat, or storey shall keep clean the passage and stair from such street or flat immediately above them downwards to the house or flat or storey possessed by them, and also cleanse any area or passage leading to any ground or back green connected therewith;

And if any flat of the tenement be unoccupied, the occupiers of the flats occupied shall keep clean the stair and passages upwards to such street, and clean the area, if there be one, or to the next occupied house; and owners or persons having charge of houses or buildings shall clean out unoccupied cellars and apartments.

The occupiers of every house or building having entrance from a common passage shall, in weekly rotation, cause such passage and steps to the street to be kept clean; provided always, that where there is no house or other occupied building having entrance from such passage, the duty of keeping clean the passage and steps to such street shall fall upon the occupiers of the several flats above, in weekly rotation. Failure of duty in any of the above respects to be followed by a penalty.

Foot-pavements to be cleansed by Commissioners.

Section 116. Commissioners shall keep properly swept and cleaned the foot-pavement of every street, so far as is reasonably practicable, and shall collect and remove from the same, so far as is reasonably practicable, all dust, ashes, rubbish, filth, and snow.

Common stairs and houses let for short periods to be whitewashed by owners.

Section 117. Owners of all common stairs and common passages shall whitewash, or at option of the owner, paint the same once every year if required to do so by the sanitary inspector, and owners of all premises occupied as dwelling-houses let for periods shorter than six months shall whitewash such premises, every part and pertinent thereof, to the satisfaction of the sanitary inspector once every year if so required by such officer; penalty in case of failure.

Burgh Surveyor, Inspector of Cleansing, M. O. H. and Sanitary Inspector may enter and cleanse dwelling-houses, etc., at expense of owner or occupier.

Section 118. It shall be lawful, at all reasonable times, for the burgh surveyor, inspector of cleansing, medical officer of health, and sanitary inspector to enter all dwelling-houses and other premises, where he has reason to believe that they are not in a cleanly condition, and to cleanse and purify the same, at the expense of the owner if they are unoccupied, but if occupied, at the expense of the occupier; Provided always that if the owner or occupier shall object to the entrance of such surveyor or other officer named, it shall not be lawful to enter without a warrant from the magistrate authorising him so to do, and the magistrate is hereby authorised to grant such warrant.

Penalties on keeping dwelling-houses in dirty and unhealthy condition.

Section 119. Every person occupying any part of a building let out as separate dwelling-houses who shall keep the same in a dirty, unwholesome, or unhealthy condition, after notice has been served upon him by the sanitary inspector to cleanse the same, shall be liable to a penalty for the offence and to a further penalty for daily continuance.

Areas, etc., to be cleansed by occupiers.

Section 120. All private courts, yards, areas, roofs of outbuildings in the same, and other places not cleansed by scavengers appointed under this Act, shall be kept clean to the satisfaction of the inspector of cleansing or sanitary inspector by or at the expense of the occupiers of the same. If such private courts, etc., shall not be so kept clean, the occupiers, or such of them as are the real offenders, shall, in addition to paying the expense of cleaning the same, be liable to a penalty; or, if the Commissioners think fit, they may cleanse all such private courts, etc., and charge the expense thereof to the burgh general assessment, or if the property is unoccupied, may charge the expense thereof to the owners.

Stables and byres to be kept clean.

Section 121. All stables and byres and areas connected therewith, and roofs of outhouses, shall be constantly kept in a clean condition satisfactory to the inspector of cleansing or sanitary inspector by the occupier thereof, under a penalty.

It shall be the duty of the inspector from time to time to examine the state of all such places, with a view to enforcing this enactment.

Horse and cow-dung to be kept off the streets.

Section 122. It shall not be lawful to deposit, except for removal, any cattle-dung upon the streets (mews or stable-lanes excepted); and no cattle-dung, wherever lawfully kept, shall be mixed with dung, soil, dirt, ashes, or filth declared by this Act to be the property of the Commissioners;

Where any cattle-dung shall be found in a street, or shall be so mixed, the inspector of cleansing shall take possession of it and sell it, the proceeds of such sale to be accounted for and applied for police purposes.

Dungsteads, etc., to be cleaned out at fixed times.

Section 123. It shall be lawful for the Commissioners, after inspection and report by the chief constable or inspector of cleansing or sanitary inspector, to regulate and limit the time within which all common necessaries and dungsteads shall be emptied and cleaned out.

If any person, under obligation by contract or otherwise to empty and clean out such places, shall fail so to do within the time limited, he shall be liable to a penalty, besides forfeiture of the dung; said dung being removed and disposed of as aforesaid.

As to removal of dung.

Section 124. Every person who shall lay, or cause to be laid, on any street any dung or manure, or hay or straw, for the purpose of removal, shall remove the same before 8 A.M. of the morning of the day on which it has been laid, from 1st October to 1st April, and before 7 A.M. from 1st April to 1st October. If the dung, etc., shall be allowed to remain on the street after said hours, the person offending shall be liable to a penalty.

Penalty for conveying offensive matter at improper times.

Section 125. Commissioners may from time to time fix the hours within which only it shall be lawful to remove any offensive matter from any premises within, into, or through the burgh; and when such hours shall have been fixed, it shall be an offence to do so at any other hours.

Any person who at any time, whether such hours have been fixed by the Commissioners or not, uses for any such purpose any vehicle not having a covering proper for preventing the escape of the contents of such vehicle or of the stench thereof, or who wilfully or negligently spills any offensive matter in the removal or passage thereof, or who does not carefully sweep and cleanse every place in which such offensive matter has been placed or unavoidably spilled, shall be liable to a penalty; and in default of the actual offender, the driver or person in charge shall be deemed the offender.

As to laying down dung on fields, nursery, or garden grounds.

Section 126. It shall not be unlawful for any person to lay down on any field, nursery, or garden ground any dung or manure, for the purpose of manuring the same; but if in any case the M. O. H. shall certify that any manure laid down in any such place within the burgh is offensive or prejudicial to health, the magistrate may order it to be removed and otherwise disposed of forthwith; failure to comply to be followed by a penalty.

Section 127. Commissioners shall have power to make bye-laws for enforcing the provisions of the preceding sections with reference to cleansing.

ENGLAND—LAW AS TO SEWERS AND SEWERAGE

In order to avoid needless repetition, those sections of the Public Health Acts for England which conform in meaning, and, it may be, in phraseology, to sections in the Public Health Acts for Scotland, will be dealt with by referring the reader to the corresponding number of the section in the latter Acts.

Public Health Act, 1875.

Section 4. Defines the terms "sewer" and "drain" (*vide* p. 262).

Sewers vested in L. A.

Section 13. Corresponds to s. 101, P.H. (Scot.) Act, 1897 (p. 315).

Power to purchase sewers.

Section 14. Corresponds to s. 102, ,, ,, (p. 315).

Making of sewers.
Powers for making sewers.
Sewage to be purified before entering a stream.
Alteration and discontinuance of sewers.
Cleansing sewers.

Sections 15, 16, 17, 18, 19 correspond to s. 103, P.H. (Scot.) Act, 1897 (p. 315).

The terms of section 17 are as follows:

"Nothing in this Act shall authorise any Local Authority to make or use any sewer, drain, or outfall for the purpose of conveying sewage or filthy water into any natural stream or water-course, or into any canal, pond, or lake, until such sewage or filthy water is freed from all excrementitious or other foul or noxious matter such as would affect or deteriorate the purity and quality of the water in such stream or water-course or in such canal, pond, or lake."

Map of system of sewerage.

Section 20. Every Urban Authority may, if they think fit, provide a map exhibiting a system of sewerage of their district, such map to be kept in their office, and to be open at all reasonable times to inspection of ratepayers of their district.

Corresponds to s. 210 Burgh Police (Scotland) Act, 1892.

Power to drain into sewers of Local Authority (21).

Use of sewers by owners and occupiers without District (22).

Power of L. A. to enforce drainage of undrained houses (23).

Power of L. A. to require houses to be drained into new sewers (24).

Section 21. Corresponds to section 110 of P. H. (Scot.) Act, 1897 (p. 316).
Section 22. Corresponds to section 111 of ,, ,, (p. 316).
Section 23. Corresponds to section 120 of ,, ,, (p. 317).
,, ,, 238 of B. P. (Scot.) Act, 1892 (p. 325).

Section 24. Where any house within the district of a Local Authority has a drain communicating with any sewer, which drain though sufficient for the effectual drainage of the house is not adapted to the general sewerage-system of the district, or is in the opinion of the L. A. otherwise objectionable, the L. A. may, on condition of providing a drain as effectual for the drainage of the house and communicating with such other sewer as they think fit, close such first-mentioned drain, and may do any works necessary for that purpose, the expenses of so doing to be deemed expenses properly incurred by them in execution of this Act.

Penalty on building house without drains in Urban District.

Penalty on unauthorised building over sewers and under streets in Urban Districts (26).

Section 25. It shall not be lawful in any *urban* district newly to erect any house or to rebuild any house which has been pulled down to or below the ground-floor, or to occupy any such house, unless and until a covered drain or drains be constructed, of such size and materials and of such level and with such fall as on the report of the surveyor may appear to the *Urban* Authority to be necessary for the effectual drainage of such house;

And the drain or drains so constructed shall empty into any sewer which the Urban Authority are entitled to use, and which is within 100 *feet* of some part of the site of such house;

Powers for disposal of sewage (27).

Power to agree for communication of sewers with sewers of adjoining District (28).

But if no such means of drainage are within that distance, then such drain shall empty into such covered cesspool or other place, not being under any house, as the *Urban* Authority shall direct.

(*Cf.* sections 238, 239, and 240 of the B. P. (Scot.) Act, 1892 (pp. 325–6).

Section 26. Corresponds to section 114 of P. H. (Scot.) Act, 1897 (p. 317), and to section 228 of B. P. (Scot.) Act, 1892 (p. 321).

Section 26. Applies to *urban districts.*

Power to deal with land appropriated to sewage-purposes (29).

Section 27. Corresponds to section 108 of P. H. (Scot.) Act, 1897 (p. 316).

Contribution to works under Agreement for supply or distribution of sewage (30).

Works of distribution of sewage to be deemed a land improvement (31).

Section 28. The Local Authority of any district may, by agreement with the Local Authority of any adjoining district, and with the sanction of the Local Government Board, cause their sewers to communicate with the sewers of such last-mentioned Authority, in such manner and on such terms and subject to such conditions as may be agreed on between the Local Authorities, or, in case of dispute, may be settled by the L. G. Board.

Provided that so far as practicable storm-waters shall be prevented from flowing from the sewers of the first-mentioned Authority into the sewers of the last-mentioned Authority, and that the sewage of other districts or places shall not be permitted by the first-mentioned Authority to pass into their sewers so as to be discharged into the sewers of the last-mentioned Authority without the consent of such last-mentioned Authority.

Notice to be given before commencing sewage-works without District (32).

In case of objection, works not to be commenced without sanction of L. G. Board (33).

(*Cf.* section 121 of the P. H. (Scotland) Act, 1897 (p. 318).)

Section 29. Corresponds to section 108 of P. H. (Scot.) Act, 1897 (p. 316.), with the exception that section 29 applies to lands held by a Local Authority.

Section 30. Corresponds to section 108 of P. H. (Scot.) Act, 1897 (p. 316).

Section 31. Is identical in terms to section 123 of P. H. (Scot.) Act, 1897 (p. 319).

As to Sewage-Works without District

Inspector to hold inquiry and report to L. G. Board (34).

Section 32. Corresponds to section 104 of P. H. (Scot.) Act, 1897 (p. 315).

Section 33. Identical with section 105 of P. H. (Scot.) Act, 1897 (p. 316).

Section 34. Identical with section 106 of P. H. (Scot.) Act, 1897 (p. 316).

Incorporation of Provisions of Towns Improvement Clauses Act, 1847 (160).

Section 160. Enacts that the provisions of the Towns Improvement Clauses Act, 1847, with respect to precautions during the construction and repair of sewers, shall for *urban* districts be incorporated with this Act.

Section 235. Gives power to a Local Authority possessed of any land, works, or other property for the purposes of sewage disposal pursuant to this Act, to borrow monies on the credit of such land and works. Power to borrow on credit of sewage land and plant.

Section 279. Enacts that where, on the application of the Local Authorities of any urban or rural districts, it appears to the L.G. Board that it would be for the advantage of such districts, or any of them, or any parts thereof, or of any contributory places in any rural district or districts, to be formed into a united district for the *making a main sewer, or carrying into effect a system of sewerage for the use of all such districts or contributory places*, the L. G. Board may *by provisional order* form such districts or contributory places into a united district. Formation of United Districts.

Section 327. Nothing in this Act shall be construed to authorise any Local Authority—

(1) To use, injure, or interfere with any sluices, flood-gates, sewers, sea-defences, or other works, made or to be made by any Commissioners of Sewers appointed by the Crown, or any sewers or other works made and to be made and used by any persons for draining, preserving, or improving land under any local or private Act of Parliament, or for the purpose of irrigating land, without duly authorised consent so to do.

Section 331. Provides that any body of persons or any person authorised by Act of Parliament to navigate navigable waters or to exact dues for navigable purposes, may at their own expense, and on substituting other sewers, drains, culverts, and pipes equally effectual and certified as such by the Surveyor of the Local Authority, take up, divert, or alter the level of any sewer, etc., constructed by the Local Authority and . . . may do all such things as may be necessary for carrying such into effect.

This section corresponds to section 189 of the P. H. (Scot.) Act, 1897.

II. Public Health Acts Amendment Act, 1890.

Part I. of this Act extends to England and Wales and Ireland, exclusive of the County of London.

Parts II., III., IV., and V. are adoptive.

An *urban* Authority may adopt all or any of the parts ; a *rural* Authority may adopt part III. so far as this Act declares that part applicable to such Authority : the adoption to be by resolution of a Local Authority at a meeting held after a notice of at least one calendar month of the intention to propose such a resolution has been sent to each member, the resolution to be duly published, and a copy thereof to be sent, (1) where any part is adopted, to the Local Government Board, (2) where part II. is adopted, to the Board of Trade, and (3) where part IV. is adopted, to a Secretary of State. The Local Government Board is empowered by section 5 to extend the Act to *rural* districts.

Part III. deals with sanitary and other provisions.

Section 16. Is identical with section 117 of the P. H. (Scot.) Act, 1897 (p. 317). Injurious matters not to be passed into sewers (16).

Section 17. (1) Every person who turns or permits to enter into any sewer of a Local Authority or any drain communicating therewith— Chemical refuse, steam, etc., not to be turned into sewers (17).

(*a*) Any chemical refuse, or

(*b*) Any waste steam, condensing water, heated water or other liquid (such water or other liquid being of a higher temperature than 110° F.)

which, either alone or in combination with the sewage, causes a nuisance or is dangerous or injurious to health, shall be liable to a penalty and to a daily penalty.

(2) The Local Authority by any of their officers, either generally or specially authorised in that behalf in writing, may enter any premises for the purpose of examining whether the provisions of this section are being contravened, and if such entry be refused, any justice, on complaint on oath by such officer made after reasonable notice in writing of such intended complaint has been given to the person having custody of the premises, may by order require such person to

admit the officer into the premises, and if it be proved that any offence under this section has been or is being committed in respect of the premises, the order shall continue in force until the offence shall have ceased or the work necessary to prevent the recurrence thereof shall have been executed. (*Cf.* section 7 of Rivers Pollution (Prevention) Act, 1876 (p. 309).)

Provision as to Local Authority making communication with or altering, etc., drains and sewers.

Section 18. (1) Where the owner or occupier of any premises is entitled to cause any drain or sewer from those premises to communicate with any sewer of the Local Authority, the Local Authority shall, if requested to do so by such owner or occupier, and upon the cost thereof being paid in advance to the Local Authority, themselves make the communication and execute all works necessary for that purpose.

(2) The cost of making the communication shall be estimated by the Surveyor of the Local Authority, but in case the owner or occupier is dissatisfied with such estimate, he may, if the estimate is under £50, apply to a court of summary jurisdiction to fix the amount to be paid for such cost, and if the estimate is over £50, have the same determined by arbitration in the manner provided by the Public Health Acts.

(3) A Local Authority may agree with the owner of any premises that any sewer or drain which such owner is required, or desires, to make, alter, or enlarge, or any part thereof, shall be made, altered, or enlarged by the Local Authority.

Extension of s. 41 of the Public Health Act, 1875.

Section 19. (1) Where two or more houses belonging to different owners are connected with a public sewer by a single private drain, an application may be made under section 41 of the Public Health Act, 1875 (relating to complaints as to nuisances from drains), and the Local Authority may recover any expenses incurred by them in executing any works under the powers conferred on them by that section from the owners of the houses in such shares and proportions as shall be settled by their surveyor or (in case of dispute) by a court of summary jurisdiction.

(2) Such expenses may be recovered summarily or may be declared by the Urban Authority to be private improvement expenses under the Public Health Acts, and may be recovered accordingly.

(3) For the purposes of this section the expression "drain" includes a drain used for the drainage of more than one building.

The provisions in Part III. of this Act which apply to rural Sanitary Authorities are sections 16,18, and 19.

Public Health Acts Amendment Act, 1907. (Adoptive.)

Part III., Sections 45–49, deals with drains and drainage.

Testing of drains on report of defects.

Section 45. Enacts that if the medical officer, surveyor, or inspector of nuisances reports to the Local Authority that he has reasonable grounds for believing that any drains of any building are so defective as to be injurious or dangerous to health, the Local Authority may authorise one of these officers to *apply the smoke or coloured-water test, or other similar test* (*not including a test by water under pressure*), to the drains, subject to consent of the owner or occupier of the building or an order of a court having jurisdiction in the place.

If on application of the test the drains are found to be defective, the Local Authority may by notice specifying the defect require the owner to remedy the same within a reasonable time, failing which, the Local Authority may themselves do the work and recover summarily the expenses thereof from the owner, or may declare the same to be private improvemnt expenses. The owner and occupier shall give all reasonable facilities for the application of any test for which consent has been given, and failing to do so shall become liable to a penalty.

Section 46. Empowers the Local Authority, on report of any of the above-named officers that any cesspool or other like receptacle for the drainage of any house, or any ash-pit or any well or disused well belonging to any house, is prejudicial to health or otherwise objectionable for sanitary reasons, to require the owner or occupier to fill up, remove, or so alter the same within a reasonable time to be specified in a written notice to be served upon such owner ; and in default, the work may be done by the Local Authority at the expense of the owner.

Section 47. Gives power to the Local Authority to provide and maintain in proper and convenient situations sanitary conveniences in or under any street, and lavatories in like positions, for public use, to make charges for the use of the same, and to make bye-laws for the management of the same and the conduct of persons frequenting the same ; or they may let such conveniences for such periods, at such rents, and subject to such conditions as to charges, as they think proper.

Section 48. Enacts that if the Local Authority are required by the owner or occupier of any premises to remove any trade refuse (other than sludge), they shall do so, and the owner, etc., shall pay them a reasonable sum for so doing, any dispute between parties to be determined by a court of summary jurisdiction. Should any question arise as to what is trade refuse, that question may be similarly decided by the court (whose decision shall be final) on the complaint of either party.

Removal of trade refuse.

Section 49. Empowers the Local Authority, on report of their medical officer or other above-named official that any building is not provided with a proper sink or drain or other necessary appliances for carrying off refuse water from such building, to require the owner by notice in writing to provide such sink, drain, or other appliances, in the manner and within a time, not less than 28 days, specified in such notice. In default, the owner shall be liable to a penalty of not more than £5, and to a daily penalty of not more than 40s.

Law Concerning Privies, Water-closets, etc.

1. **Public Health Act, 1875 ;** Sections 53–41.
2. **Public Health Acts Amendment Act, 1907 ;** Sections 34–49.

Section 35. Makes it unlawful newly to erect any house or to rebuild any house pulled down to or below the ground-floor, without a sufficient water-closet, earth-closet, or privy and an ash-pit furnished with proper doors and coverings, under a penalty.

Penalty on building houses without W.C. or privy accommodation.

Section 36. Empowers a Local Authority, where any house in their district on the report of the surveyor or inspector of nuisances is without a sufficient w. c., earth-closet, or privy and ash-pit, to require the owner or occupier of the house to provide such conveniences, within a reasonable time specified within the notice. Where the owner or occupier fails to comply, the L. A. may, at expiration of the time, do the work required to be done, and recover the expenses from such owner or occupier ;

Power to Local Authority to enforce provision of W.C. or privy accommodation.

Provided that where a w. c., earth-closet, or privy has been and is used in common by the inmates of two or more houses, or if in the opinion of the L. A. such convenience may be so used, they need not require the same to be provided for each house.

Section 37. Any enactment in force in a district of a L. A. requiring the construction of a water-closet, shall be deemed to be satisfied by the construction, after approval of the L. A., of an earth-closet.

Provisions as to earth-closets.

Any L. A. may, in respect of any house having an approved earth-closet, dispense with the supply of water.

Any L. A. may undertake or contract for the supply of dry earth or other deodorising substance to any house for the purpose of any earth-closet.

In this Act the term "earth-closet" includes any place for the reception and deodorisation of faecal matter which is constructed to the satisfaction of the L. A.

Section 38. Deals with privy accommodation for factories (see p. 237).

Section 39. Any Urban Authority may, if they think fit, provide and maintain in proper and convenient situations urinals, water-closets, earth-closets, privies, and ash-pits, and other similar conveniences for public accommodation.

Provision as to public conveniences.

Drains, water-closets, etc., to be kept properly.

Section 40. Every L. A. shall provide that all drains, water-closets, earth-closets, privies, ash-pits, and cesspools within their district be constructed and kept so as not to be a nuisance or injurious to health.

Section 41. On a written complaint of any person to a L. A. that any drain, water-closet, etc., in any premises within their district is a nuisance or injurious to health (*but not otherwise*) the L. A. may, by writing, empower their surveyor or inspector of nuisances, after 24 hours' written notice to the occupier of such premises, or in case of emergency without notice, to enter such premises, and cause the ground to be opened, and examine such drain, water-closet, etc. If the drain, etc., be found to be in proper condition, the ground is to be properly closed and any drainage made good as soon as can be, all at the expense of the L. A.; but if found to be in a bad condition, or to require alteration or amendment, the L. A. shall forthwith cause written notice to be given to the owner or occupier of the premises requiring him forthwith or within a reasonable time therein specified to do the necessary works. If such notice be not complied with, the notified person shall be liable to a penalty for every day during which the offence continues, and the L. A. may execute the work and recover summarily from such person the expense thereof.

2. The Public Health Acts Amendment Act, 1907; Part III. (Adoptive.)

Section 34. Extends the meaning of the foregoing section as follows:—Section 41 of the Public Health Act, 1875, shall have effect as if for the words "(but not otherwise)" there were substituted the words "or where on the report in writing of their surveyor or inspector of nuisances the Local Authority have reason to suspect that any such drain, water-closet, earth-closet, privy, ash-pit, or cesspool is a nuisance or injurious to health"; and section 35, declares that for the purposes of the Public Health Act, 1875, any cistern used for the supply of water for domestic purposes, so placed, constructed, or kept as to render the water therein liable to contamination, causing or likely to cause risk to health, any gutter, drain, shoot, stack-pipe, or down-spout of a building so insufficient or so defective as to cause damp in such building or adjoining building, and any deposit of material in or on any building or land which shall cause damp in any such building or adjoining building so as to be dangerous or injurious to health, shall be deemed a nuisance within the meaning of said Act.

Section 36. Enacts that rain-water pipes shall not be used as soil-pipes; section 37, that no water-pipe, stack-pipe, or down-spout shall be used to serve or act as a ventilating shaft to any drain; and section 38, that before any drain shall be made to communicate with any sewer of the Local Authority, the same shall be laid open for examination by the surveyor, and the communication shall not be made until the surveyor shall certify that such drain may be properly made so to communicate.

Section 39. Deals with the provision and conversion of closet-accommodation. Within one month after the plan of a proposed new building has been deposited, and where there is a sufficient and reasonably available supply of water and an adequate sewer near the proposed site, the Local Authority may by written notice require the applicant to provide such new building with such number of proper and sufficient water-closets and slop-closets, or with closets of either class as are deemed necessary. On the report of the medical officer of health or surveyor or inspector of nuisances to the Local Authority that any building is not adequately supplied with closet-accommodation and that the same class of closet cannot be properly extended, the Local Authority, provided there are a sufficient supply of water and a sewer, may call upon the owner or owners to provide water-closets and slop-closets, or closets of either class. If the owner fail to comply with such notice so to do, the Local Authority not less than 14 days after service of such notice, may themselves do the necessary work and recover summarily the expenses so incurred from the owner. The Local Authority are also empowered, where there are a sufficient supply of water and a sewer, to require the owner of any building already supplied with closet-accommodation to provide in its stead water-closet or slop-closet accommodation during alteration of the building. If the owner fail to comply, the necessary change may be made by the Local Authority as stated above, but where any work is done by the Local Authority in default of the owner in respect of a pail-closet, the Local Authority shall bear the expenses of the work, and in the case of any existing closet-accommodation other than a pail-closet, one-half of the expenses shall be borne by the Local Authority and the remainder by the owner or owners. The expression " closet-accommodation " in this section is defined to mean and include a receptacle for human excreta, its structure, fittings, and apparatus; "pail-closet," a movable receptacle for human excreta; "water-closet," closet-accommodation adapted or intended to be used in connection with the water-carriage system, and having provision for flushing the receptacle with fresh water and communication with a sewer; "slop-closet," closet-accommodation, as in a water-closet with like provision as to flushing and sewer connection, but where the flush-water is the slops or household waste liquids or rain-water.

Section 44. Empowers the Local Authority to require the owner of any inn, public-house, beer house, etc., or place of public entertainment to which no urinal is attached, to provide the same, and by section 43, the Local Authority may require the removal or alteration of any urinal which is so placed or so constructed, as to be a nuisance or offensive to public decency. (*Vide* p. 328.)

Scavenging and Cleansing

Public Health Act, 1875; Sections 42–50.

Local Authority to provide for street cleansing and refuse removal.

Section 42. Every L. A. may, and when required by the Local Government Board, shall themselves undertake or contract for—

(*a*) Removal of house-refuse from premises;

(*b*) Cleansing of earth-closets, privies, ash-pits, and cesspools;

either for the whole or part of their district.

Every Urban Authority, and, when invested with the necessary powers, every Rural Authority may, and when required by the Board shall, themselves undertake or contract for—

(*a*) Cleansing of streets;

(*b*) Watering of streets;

either for the whole or part of the district.

All matters collected by the L. A. or contractor may be sold or otherwise disposed of.

Any person removing or obstructing the L. A. or contractor in the removal of such matters shall be liable to a penalty; provided that any occupier shall not be so liable who removes matters produced on his own premises, which are intended for sale or for use, and are kept without nuisance.

Penalty on L. A. for neglect.

Section 43. Provides a penalty on neglect of a Local Authority to remove house-refuse, or to do such other things as are named in the foregoing section which they are bound to do.

Power to L. A. to make Bye-laws.

Section 44. Gives a Local Authority power to make bye-laws regarding the following:—

(1) Cleansing of footways and pavements;

(2) Removal of house-refuse from premises;

(3) Cleansing of earth-closets, privies, ash-pits, etc., where they themselves do not undertake or contract for such work.

An Urban Authority may also make bye-laws for—

(4) Prevention of nuisances arising from snow, filth, dust, ashes, and rubbish;

(5) Prevention of keeping of animals on any premises so as to be injurious to health.

The Model Bye-Laws of the English Local Government Board demand that (1) every *earth-closet*, furnished with a *fixed receptacle for fæcal matter and with suitable means for the frequent and effectual application of dry earth to such matter*, shall be cleansed *at least once in every* 3 *months*; (2) every *earth-closet* furnished with a *movable receptacle* and with suitable means for use of dry earth, *once at least every week* ; (3) *every privy*, with a *fixed receptacle for fæcal matter, once at least every month* ; (4) *every privy* with a *movable receptacle, once every week* ; (5) *every ash-pit*, used only as a receptacle for ashes, dust, and dry refuse, *once every week* ; (6) *every ash-pit*, used in connection with a privy as a receptacle for fæcal matter, together with ashes, etc., *once every week* ; and (7) *every cesspool, once in every 3 months.*

Power to L. A. to provide dust receptacles and buildings for dust, ashes, etc.

Section 45. Gives power to any Urban Authority to provide, in proper and convenient situations, receptacles for the deposit and collection of dust, ashes, and rubbish ;

And to provide fit buildings and places for the deposit of any matters collected by them in pursuance of this Act.

Houses to be cleansed, etc., on certificate of M. O. H., or of two medical practitioners.

Section 46. Where, on the certificate of the M. O. H. or of any two medical practitioners, it appears to any Local Authority that any house or part thereof is in such a filthy or unwholesome condition that the health of any person is affected or endangered thereby, or that the whitewashing, cleansing, or purifying of any house or part thereof would tend to prevent or check infectious disease, the L. A. shall give notice in writing to the owner or occupier of such house or part thereof to whitewash, cleanse, or purify the same, as the case may require. (*Cf.* section 40, p. 329.)

If the person to whom notice is so given fails to comply therewith within the time therein specified, he shall be liable in a penalty for every day during which he continues to make default, and the L. A. may, if they think fit, do the necessary work and may recover in a summary manner the expense incurred thereby from the person in default.

Penalty in respect of keeping swine and of other nuisances on premises.

Section 47. Any person who in any urban district—

(1) Keeps any swine or pig-stye in any dwelling-house, or so as to be a nuisance to any person ; or

(2) Suffers any waste or stagnant water to remain in any cellar or any place within any dwelling-house for 24 hours after written notice to remove the same from the Urban Authority ; or

(3) Allows the contents of any w. c., privy, or cesspool to overflow or soak therefrom ;

shall be liable to a penalty for every day of continuance after notice ; and the Urban Authority shall cause the same to be abated, and may recover expense of so doing from the occupier of such premises.

Section 48. Makes provision for obtaining an order for cleansing offensive ditches lying near the boundaries of districts.

This section is exactly the same as section 41 of the Public Health (Scot.) Act, 1897 (see p. 325).

Power to L. A. to compel removal of accumulations of filth, etc.

Section 49. Gives power to an urban Local Authority, on the certificate of the inspector of nuisances, to remove any accumulation of manure, dung, soil, or filth, or other offensive or noxious matter, within 24 hours after failure of person to comply with a written notice to that effect.

This section is practically identical with the second part of section 42 of the P. H. (Scot.) Act, 1897, except that in the latter the provision only applies to scavenging districts (see p. 329).

2. Public Health Acts Amendment Act, 1890; Adoptive Sections.

Part III. Section 20. Enacts that where an Urban Authority provide and maintain for public accommodation any sanitary conveniences, such Authority may—

(1) Make regulations with respect to the management thereof and make bye-laws as to the decent conduct of persons using the same ;

(2) Let the same for any term not more than 3 years at such rent and on such conditions as they may think fit ;

(3) Charge fees for the use of water-closets so provided, as they may think proper.

No public convenience, after adoption of this part of the Act, shall be erected in any street without the written consent of the Urban Authority, and any person contravening shall be liable to a penalty.

This section does not apply to sanitary conveniences in any railway station yard erected by a railway company.

Section 21. Makes provision for penalties against any person who injures or improperly fouls any sanitary convenience, or anything in connection therewith, which is used in common by the occupiers of two or more separate dwelling-houses or by other persons.

L. A. to compel suitable provision of sanitary conveniences in workshops, etc.

Section 22. Requires that every building, used as a workshop or manufactory, whether erected before or after the adoption of this Part of the Act in any district, shall be provided with sufficient and suitable accommodation in the form of sanitary conveniences, having regard to the number of persons employed, and with proper separate accommodation for persons of each sex.

Where an Urban Authority, on the report of their surveyor, believes that the provisions of this section are not complied with in any such building, they may by a written notice require the owner or occupier of the building to make such alterations and additions therein so as to provide such sufficient, suitable, and proper accommodation. Neglect or refusal to comply with any such notice shall render the person liable to a penalty. Where this section is in force, section 38 of the Public Health Act, 1875, shall be repealed. (*Vide* also p. 237.)

Section 24. Forbids any portion of a room extending immediately over a privy (not being a water-closet or earth-closet) or immediately over any cesspool, midden, or ash-pit, to be used as a dwelling-place, sleeping-place, or place of habitual employment of any person.

Any person who occupies, or suffers to be occupied, any such room after notice by the L. A. of not less than seven days, shall be liable to a penalty.

Power to make Bye-laws for removal of offensive matters (see p. 333).

Section 26. An Urban Authority may make bye-laws in respect of the following matters—viz.

(1) Prescribing the times for removal or carriage through the streets of any fæcal or offensive or noxious matter or liquid, whether from within, without, or through their district ;

(2) For providing that the vehicles or vessels used therefor shall be properly constructed and covered to prevent the escape of such matter or liquid ;

(3) For compelling the cleansing of any place whereon any such matter may have been dropped or spilled in such removal or carriage.

When a L. A. themselves undertake or contract for the removal of house-refuse, they may make bye-laws imposing on the occupier of any premises duties in connection with such removal so as to facilitate such work of removal.

Section 27. Provides for keeping clean all common courts and passages.

CHAPTER X

PREVENTABLE DISEASES

Sanitary science or Preventive medicine has as one of its chief objects the prevention of disease *ab initio*, and of the spread of certain communicable diseases, by removing the conditions by which they may be generated or propagated. In order to secure this end, all civilised States have made important enactments which operate not only within their own borders, but also in the relations of each to the other, with respect to the specific infectious and contagious diseases. In respect of the class of infective diseases, and, indeed, of other preventable diseases, such as scurvy in seamen, and of inhalation or ingestion of substances used in trade-operations which are inimical to health, an immense and complicated machinery has been erected and kept in motion for their prevention. The State obviously only deals with those causes which are beyond ordinary individual control, such as the effects of employment on children and women in factories and workplaces, or which operate by carelessness in one or another form, such as the spread of infective diseases, the sale of food unfit for human use, etc. These, however, are capable to a large extent of being controlled and regulated by regulations enacted by a controlling authority, and especially, if disobedience thereto is followed by penalties. The object of State control in this connection is the protection of the mass of the people against the carelessness and negligence of the individual. The preventable diseases are incited and initiated by a variety of causes, among which may be named overcrowding and filth, atmospheric pollution of dwellings, insanitary conditions of sewage-disposal system, and contact with the infective sick or with infected material. To this class also belong those diseases which are communicable from animal to animal and from animals to man. The chief characteristic of the specific preventable diseases is their communicability by a specific contagium or infective agent, which, although well recognised for many centuries, since, indeed, the institution of the Mosaic Code, only became intelligible since the discovery of their microbic origin. It is not necessary to consider the various theories which have been propounded from time to time regarding the causal factors of these diseases, since the discovery of microbes amply accounts for all their phenomena. Koch's rules whereby an infective disease should be so designated only apply, it must be understood, to several of these diseases, because in respect of some of these, specific micro-organisms have not yet been discovered and isolated. Koch's requirements are as follow :—

> (1) A micro-organism must be found in the blood or tissues of the person or animal that is suffering, or has died from the disease ; (2) this microbe taken from the body must be capable of artificial cultivation in suitable culture-media,

in a series of generations, out of the body, with no possibility of any other microbe being introduced during the process ; (3) the microbe from one of these cultures, on being inoculated into the body of a healthy animal, ought to reproduce the same phenomena of disease as those exhibited in the animal or person from whom it was originally taken ; and (4) the microbe must be proved to have multiplied in the body of the animal inoculated.

The principal preventable diseases are the following—viz. *Smallpox, chicken-pox, scarlet fever, measles, rötheln or German measles, typhus, enteric, relapsing, yellow,* and *continued fevers, cholera, influenza, whooping-cough, diphtheria, erysipelas, puerperal fever, pneumonia, mumps, cerebro-spinal meningitis, plague* and, with a limited infectivity, *tuberculosis.* These may be considered as of the infective type. Glanders, anthrax (known as wool-sorters' disease and malignant pustule in man), foot-and-mouth disease, venereal diseases, Egyptian and other forms of ophthalmia, leprosy, rabies, and to some extent malaria, may be reckoned as of the contagious type.

Types of Micro-organisms.—These may be divided into the following morphological types—viz.

1. *Micrococcus,* comprising the *diplococcus, sarcina* or *tetracoccus, streptococcus, staphylococcus.*
2. *Bacillus.*
3. *Spirillum.*

To the first form belong the micro-organisms of fowl-cholera, swine-fever, measles, scarlet fever, smallpox, cow-pox, foot-and-mouth disease, pneumonia, erysipelas, puerperal fever, and of other diseases ; to the second, those of anthrax, tubercle, glanders, enteric fever, cholera, diphtheria, tetanus, leprosy, plague, and of others ; and of the third, that of relapsing fever.

Nature of Infective Material.—Whether this is known by the names of *effluvium, miasma, influence, virus, fomites, infection, contagium,* or by any other name, infective matter is essentially particulate in character, and is capable of being borne by or upon different media, as air, food, clothing, and various others. It is composed of micro-organisms or their spores or both. Being particulate, therefore, it obeys natural laws ; because of its lightness, it is easily air-borne when in a dry condition, but it is held in retention by moist surfaces ; it cannot penetrate any interposing barrier, even of paper, and much less, walls and doors. Destruction of infective material, therefore, resolves itself into annihilation of organisms and spores.

When pathogenic organisms gain a foothold in the body they exhibit elect seats of operative activity. Upon this basis, they may be divided into three classes, viz. : (1) those which mainly involve the skin ; (2) those which invade the upper internal mucous tract of pharynx and air-passages ; and (3) those which implicate the lower mucous tract, intestines, etc. To the first class belong chicken-pox, smallpox, erysipelas, scarlet fever, measles, German measles, and others, this class being known as the exanthematous group ; to the second belong diphtheria, foot-and-mouth disease, whooping-cough, mumps, ophthalmia, influenza, pneumonia, and pulmonary tubercle; and to the third, cholera, enteric fever, yellow fever, and puerperal fever. Several diseases of this type refuse to be so arbitrarily classified, in respect that some of them invade more than one of the above tracts: but while the infective material in each infective disease may be found in more than one of the discharges of the patient, it is most abundant at the elect seats of operation. The habitat of micro-organisms in the body is determined by their life-history; for example, the *B. diphtheriæ* cannot grow without a plentiful supply of air, hence it is found in those situations most calculated to meet this requirement. The evil results which follow the development of pathogenic organisms in the body are due to the products which they form out of albuminous substances in the course of their growth and multiplication. These being derivatives of albumen have been called *albumoses*, and because of their poisonous action on the bodily functions, *toxines*. Such albumoses or toxines may be formed directly in the blood itself, or they may be absorbed into the blood from the tissues. In diphtheria, for example, they are formed in the mucous membrane of pharynx or air-passages, and after absorption produce profound physical depression, and, it may be, after-paralysis of some part of the body; the toxine formed by the *B. tetani* produces cerebro-spinal irritation, evidence of spinal disturbance being shown by the convulsive contraction of the masseter and other muscles of the lower jaw.

While communicable diseases may be seen in isolated cases, more usually they betray their presence by several persons being attacked within a limited short time. They are thus said to be of one of three forms, viz.: the *epidemic*, the *endemic*, and the *pandemic*. An epidemic disease may be defined as one which, independent originally of local causes, attacks a number of persons in a population within a short time. The cause, therefore, belongs more to the people than to the place. An endemic disease is one which is dependent upon local conditions, attacks individuals in communities, and is more or less continuously prevalent. The cause has its origin more in the place than in the people. A pandemic disease is one which attacks the bulk of the population of a country, or numbers of population of different countries, about one time. Of the first and last it may be said that the infective material is conveyed from man to man by intercommunication, and from nation to nation by trade-routes or by atmospheric agency.

Influence of Climatic Conditions on Infective and Contagious Diseases.—Climate may be defined as a resultant of different factors as annual range and extremes of temperature, atmospheric pressure, humidity, prevalent winds, exposure, and certain other local conditions. The effects of climatic conditions manifest themselves markedly with respect to certain classes of diseases, but so far as is known, not with respect to others; for example, pulmonary ailments mostly prevail in winter and spring when temperatures are low, and infective diseases of the abdominal type, mostly in summer and autumn. But climatic conditions also exercise a determining influence on the infective type of diseases generally.

Small-pox prevails most in winter and spring, least in the other seasons. The temperature has a notable influence on its spread and decline. Below 50° F. the disease tends to spread, above that temperature it tends to decline. Baldwin Latham has put forward the view that smallpox is always preceded by a long period of dryness of the ground, measured by the absence of percolation.[1] If this datum be looked at in the light of local conditions, however, it would seem to be very doubtful in its general accuracy at least, or constant in its application. It is important at the same time, in considering the possible relations of smallpox outbreaks to climatic conditions, to discriminate as to the local origin of the disease; for if the disease be imported from without, and there be a vulnerable population in the locality, climatic conditions play but a relatively unimportant part in the spread of the disease. Brückner, from a survey of the records of the rainfall of the world over a period of centuries, has arrived at the conclusion that, since 1700, the most of the surface of the land of the globe has been subject to recurrent alternated spells of cold and wet weather on the one hand, and of warm and dry weather on the other, and that the intervals between the middle of two such succeeding periods are approximately thirty-five years. Newsholme has applied this test of alternative excess and deficiency of rainfall to the incidence and prevalence of smallpox in London, and he has found that only up to a certain point would the theory seem to be applicable to the facts.[2]

Scarlet fever prevails most in the last six months of the year, the maximum being in the December quarter. A temperature of about 60° F. favours the extension of the disease, a fall to 50° F. tends at once to arrest it. But the dissemination of the disease from milk must not be overlooked. This association is too well established to be gainsaid. Such outbreaks are more independent of climatic conditions. In this connection the English Local Government Board Report on the Macclesfield outbreak in 1889 may be studied with profit.

In many of the outbreaks associated with milk-supplies there is most commonly a history of previous contamination of the milk by a milker or a milk-carrier who suffers from the disease or who is associated with others who are suffering; in short, the history of human intervention. But in addition to these, there have from time to time been outbreaks where the cause could not be traced to human agency and in which the facts pointed to an origin in the cow herself. The first of these unusual outbreaks occurred in 1882, in St Giles and St Pancras districts of London. Buchanan, in the investigation of the facts and the cause, came to two conclusions respecting the latter: (1) that there existed no discoverable means by which the milk delivered coincident with the period of outbreak could have been infected from the human subject, and (2) that a cow at a particular farm from which the milk came had been ill from the time of calving, one of the symptoms or sequelæ of the illness being loss of hair in patches. Klein, asked by the Local Government Board to investigate the subject, reported that especially when a cow was in milk, a definite disease could be produced in the animal by means of scarlatinal infection, which could be transmitted by inoculation from one animal to another.

In 1885, an epidemic of scarlet fever broke out in Marylebone, London. Wynter Blyth, the medical officer of health, reported to the Local Government Board that the outbreak was evidently connected with a particular milk-supply which was traced to have come from a farm at Hendon. Power investigated the cause of this epidemic for the Board. The milk in question had been distributed in detail in St Pancras, Hampstead, St John's Wood, and Hendon. Except from St John's Wood, the history of each district was that up until the end of November or beginning of December of that year, it had been remarkably free from scarlet fever, but that then cases rapidly developed in families who proved, on inquiry, to be customers of the milk-dealer who retailed the Hendon-farm milk. No person at the Hendon farm or associated with it was found to be ill of the disease. Power was able, by the help of certain facts which explained the escape from attack of the St John's Wood consumers, to confine the likely source of the infected milk from this farm to a particular cowshed, and, therefore, to particular cows. Examination of these animals demonstrated that in November and December they had been attacked by an eruptive disease of the udder and teats, which had been brought to the farm by some new cows from Derbyshire.[1] Again, Klein was asked to investigate; products of the affected cows were sent to him, and two of the cows were bought and conveyed to London for observation. From the products, Klein reported the finding of a streptococcus which grew in gelatin in opaque white colonies without liquifying the medium, grew in milk which it clotted, and which, when subcultured and injected into calves, produced all the manifestations of the Hendon disease, except sores on the teats and udders, but when injected into newly-calved cows did produce characteristic ulcers on the teats in addition to the other signs.[2]

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[1] *Proc. Roy. Meteor. Soc.*, No. 19, 1890.

[2] *B.M.J.*, vol. ii., 1902, p. 26.

In March, 1889, an epidemic of scarlet fever and scarlatinal sore-throat broke out suddenly in the Garnethill district of Glasgow, the source of which was milk from a particular farm in the country. Investigation could not discover any trace of any illness in connection with the farm, either at or before the outbreak of the epidemic in the city. The late Dr J. B. Russell, then medical officer of health, found, however, that two cows on the farm were suffering from ulcers on the teats indistinguishable from those found on the teats of the affected animals in the Hendon case. The animals were removed to the Veterinary College in the city for observation. Both animals were found to be casting epidermis and hair copiously. A calf fed on the milk of one of them was attacked by an acute febrile illness which endangered its life, the convalescent state showing desquamation of epidermis and hairs.[3] The milk of one of the animals was examined and was found to contain small curdled masses, which on microscopic examination were found to contain micrococci in short chains. The late Dr Neil Carmichael, who conducted the bacteriological investigation, obtained milk from the udder, after adoption of means to prevent external contamination, by passing a sterilised cannula into one of the milk-ducts. On cultivation, it yielded a pure culture of micrococci in zooglea-like masses. From the deeper layers of the skin of the calf which had been fed on the milk of the cow, a little blood was obtained under sterile conditions. It also yielded growths of similar naked-eye and microscopic appearances.[1]

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[1] *Fifteenth Annual Report of Local Government Board* (*Supp.*), 1885–1886.

[2] *Sixteenth Annual Report of Local Government Board* (*Supp.*), 1886–1887; *Seventeenth Annual Report* (*Supp.*), 1887–1888.

[3] *Sanitary Journal*, May 16, 1888.

In 1903, Lincoln for the second time suffered from an outbreak apparently identical with the "Hendon disease." On this occasion, the medical officer of health traced all the cases to one particular dairy in the city. On the cows being examined, some of them were found to be affected by a vesicular eruption on the teats and other parts like the cows at Hendon. The clinical features of the human attacks were: on first day, sore throat, vomiting, sometimes diarrhœa, followed in many cases two days later by scarlatiniform rash, with desquamation in many cases about a week later. Most of the patients in the outbreak fell ill on the same day. Forty cases were notified, fourteen of these in one household. In the previous similar outbreak in Lincoln, over one hundred persons were attacked, four deaths being ascribed to the disease.[2]

There is at least one thing common to the disease which has been known for centuries as scarlet fever and the above illnesses traceable to milk—viz. micrococcal forms of micro-organisms. There can be little doubt whatever that micrococcal infections are common, the chief symptoms of which are sore throat, fever, skin-rashes, and desquamation, the micrococci being found abundantly in swabs taken from the inflamed tonsils and throat, and, further, that between a mild attack of true scarlatina and a septic sore throat accompanied by a skin-rash, there is much difficulty to distinguish; indeed, the question is bound to arise for discussion soon, whether not a little of the disease notified as scarlet fever is not merely micrococcal infections of different kinds, for it is far from certain what is the so-called *Streptococcus scarlatinæ*. Mervyn Gordon's investigations on the causative organism or organisms of scarlet fever[3] indicate this difficulty and uncertainty. How far, indeed, scarlet fever is ever uncomplicated by the invasion of a single and only micrococcal organism is not known; on the other hand, it has to be acknowledged that usually the *S. pyogenes* is commonly present along with the organism to which some have given the name *S. scarlatinæ*.

If one may judge from statistics, the mortality from the disease has been on the decline during the last thirty years, as the following table quoted from McVail (*op. cit.*) will show :—

Scarlet Fever

Deaths per Annum per Million Living

	1861-1870	1871-1880	1881-1890	1891-1900
England and Wales	890	649	312	156
Scotland . .	910	780	290	190

There is good reason to say that, certainly during the last thirty years, the type of disease which has prevailed has been much less virulent, and probably to that fact must be ascribed the diminishing mortality.

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[1] *Carmichael. Proc. Philosoph. Soc. of Glasgow*, vol. xx., 1889–1889, p. 234.

[2] *B.M.J.*, vol. i., 1903, p. 1225. *Vide* also; McVail. The Prevention of Infectious Disease, 1907, p. 156.

[3] *Thirteenth Report of Medical Officer of Local Government Board.*

But the numbers of cases do not seem to be diminishing; with every fresh crop of susceptible children the disease appears, and few would seem to escape, despite the better-understood principles of isolation at home and facilities for isolation in hospital. According to Millard and others, free hospital isolation of cases does not seem to have much, if any, appreciable difference in the numbers of those attacked compared with other places where hospital isolation has not been so rigidly enforced. Nevertheless, so far as can be judged, it would appear that hospital isolation has done much, especially in the case of poor, ill-clad, and ill-fed children, to diminish the serious sequelae of the disease, such as nephritis. In this, it seems to us, is the chief value of hospital isolation. On the other hand, to be effective, the isolation in hospital must cover the whole period of infectivity of each individual case. It is not enough to fix a standard time for all cases during which all without exception should be isolated, no matter whether that period be four weeks, six weeks, or two months. The standard should not be time or time-limit, but one of freedom from infectivity. While for administrative purposes it is, perhaps, impossible to do without an average time-limit, that must in every case be determined by the state of the patient relative to freedom from infection. For want of due consideration of this must be attributed the "return" cases about which so much has been written of recent years. Just as diphtheria patients apparently recovered may be the harbourers of the bacillus in their air-passages, and enteric fever patients may be "carriers," so scarlet fever patients discharged from hospital with discharges from nose, ear, or throat, or with inflamed throats, or with sores around nose, mouth, or ears may still be infective to others who are susceptible. The time has probably arrived when Local Authorities, especially those of populous centres, may find it of administrative value to institute convalescent homes for patients discharged from infectious hospitals to be placed under observation, and for better restoration to health, before being sent back to their homes.

Measles is a disease chiefly of the months of November, December, January, May, and June. The most favourable temperature for its spread is between 45° and 50° F., while above 60° F., or below 40° F., it receives a check. Babés isolated a micrococcus which he believed to be the causal factor, but his conclusions have been questioned.

Typhus fever prevails most largely at those seasons of the year when the poor, half-starved, and uncleanly live in overcrowded rooms. It therefore is more common in the winter than in the summer months, although there is a rise in the mortality in July, explainable in some cases by the same conditions. The infective matter—for as yet no specific micro-organism has been discovered—although very virulent within close range of those affected, is neutralised by plentiful supplies of air. From the patient a characteristic odour is exhaled, which is apt to adhere to clothing. Typhus fever more than any other disease of the infective type has succumbed to the influence of improved sanitary environment. It is now a comparatively rare disease.

Cerebro-spinal meningitis may also, in the main, be reckoned as a disease of the winter and spring months, and much less of the summer and autumn months. It is not unlikely that its prevalence, like typhus fever, is due to aggregation of the poor and uncleanly in poorly ventilated, and, therefore, air-polluted apartments. It has not been found to any extent in the colder zones, and it has not invaded tropical regions to any great extent.

Enteric fever is most common in the autumn months. It would therefore appear that the climatic conditions then prevalent are most favourable for the development of the Gaffky-Eberth bacillus. It is more a disease of rural than of urban communities, and epidemics in the latter are, in many instances, imported from the former. Whether this fact is alone due to the less attention which is given in rural districts to the disposal of excreta, it is difficult to say, but there is little doubt that it is an important factor in its causation, by reason of consequent pollution of water-supplies. October is the month of its maximum prevalence. The organism of the disease is usually conveyed by infected milk or water, but in privy-midden towns, where the disease is said to be more prevalent than in ash-bin towns, there are good grounds for believing that the common house-fly and other winged insects are important factors in the propagation and extension of the disease, because of their foul-feeding habits, and consequent convection of infective material to domestic food-supplies on their antennæ, wings, or legs.

With regard to the part played by flies as carriers of infection, the Local Government Board authorised in 1908 an investigation on the subject by Monckton Copeman and Nuttall. The preliminary report [1] gives a large amount of interesting information regarding the more important species of flies found in houses, and the breeding of flies. It would appear that ten or eleven species may be found, but the commonest are the common house-fly, *Musca domestica*, the lesser house-fly, *Homalomyia canicularis*, the blue-bottle fly, *Calliphora erythrocephala*, and the *Muscina stabulans*. It is further shown that at an average temperature of 70° F., the eggs of these flies hatch in 24 hours, the larval stage occupying eleven days, and the pupal stage an average of ten days.

Klein has examined a number of flies with reference to their acting as carriers of the *B. typhosus* and *B. coli communis*, with the result that the latter was undoubtedly found, as also an organism indistinguishable from the former in morphological, cultural, and agglutinative characteristics.[2] Since the infective matter is thrown out of the body chiefly by stools and urine, great care should be exercised in their disinfection.

Summer diarrhœa, too, prevails more extensively in summer and autumn than in winter. Ballard's report on this subject to the English Local Government Board in 1889 deals exhaustively with the cause and incidence of summer diarrhœa. The inquiry was undertaken because of the high mortality from diarrhœa which annually recurred in Leicester. Preliminary inquiry, however, at once showed that many other places were, in this respect, to be ranked with Leicester. Before Ballard's investigations, it had been observed that a high diarrhœal mortality was contemporary with a high atmospheric temperature, and a low mortality with relatively low temperatures, but he was able to show that the temperature of the surface-layers of the earth was probably of more importance than the temperature of the air. His data, indeed, go to show that as soon as a 4-foot earth-thermometer indicated a mean earth-temperature of 65° F., the summer rise of mortality from diarrhœa commenced, irrespective of the air-temperature or, indeed, of the temperature of the uppermost one-foot layer of soil. His second important conclusion was that the composition of the surface-layers of the ground played a not unimportant part; for example, summer diarrhœa was not found to prevail in epidemic form in houses the foundations of which were built on solid rock, but that it did prevail to a considerable degree among the occupants of dwellings whose foundations were laid on permeable soil, subject to fluctuation in relative proportions of ground-air and ground-water. Thus sandy soil favours and a clayey soil hinders or is not favourable to the genesis and prevalence of the disease. Excrementitious pollution of the soil is an additional incentive factor. Even dwellings built upon fissured rock strata, the fissures of which contain such pollution, show a relatively higher prevalence. The third conclusion which he reached, as inducive of the disease, is density of buildings on areas by which the free movement of air is restricted or prevented, the most pernicious arrangement of houses being that of the kind known as "back-to-back" houses. While the existence of dirt, want of light, and defective ventilation are contributory factors, there has been little or no evidence to indicate that even the use of a polluted water-supply operates as an important factor.[1] The *B. enteritidis sporogenes* is most commonly found in the months of summer and autumn.

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[1] *Local Government Board Reports* (New Series, No. 5).

[2] *B.M.J.*, vol. ii., 1908, p. 1150.

Enteric Fever and Slaughter-Houses. *Local Government Board Report*, by Spear, 1889.

Yellow fever is confined to climates very different from that of these islands. Its range of distribution is limited to the West Coast of Africa, the West Indies and Gulf of Mexico, some parts of South America, and to limited tracts of the Atlantic and Pacific seaboards of North America. Within these limits it is usually endemic. Strangers are more liable to be seized than natives, since the latter have become acclimatised. Immunity is only established after long residence, and even then is but imperfect, although second attacks are comparatively rare. A temperature below 65° F. prevents the diffusion of the disease. The spread of the disease in Sept. 1865 among the population of Swansea from a ship which arrived in port infected with yellow fever must be attributed to the high temperatures which prevailed at the time. Twenty inhabitants of the town were seized on that occasion. The specific micro-organism has not yet been isolated; more than one has been declared to be the causal factor, but not one has been proved beyond doubt.

In 1897, Sanarelli described the *B. icteroides*, and Sternberg in 1890, the *Bacillus x*, both of which were suspected at the time to be the *causa causans* of this disease. But Reed and Carroll[2] showed that they belonged to the hog-cholera group of the coli bacilli. Durham and Myers studied this disease, from which the latter unfortunately lost his life. A full account of their researches is yet to be given, but they were unable to isolate any organism which could be absolutely shown to be the specific micro-organism of the disease. Reed,

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[1] *Lancet*, vol. i., 1898, p. 897.
Local Government Board, Supplementary Report, 1889.

[2] *Jour. Exper. Med.*, Dec. 1900.

Carroll, and Agramonte, at the Pan-American Medical Congress in 1901, presented a communication embodying their reasons for the belief that the mosquito, *Culex fasciatus*—now known as *Stegomyia fasciata,*—serves as an intermediate host for the parasite of yellow fever. The whole subject is still under investigation: but this view may now be held to be well established.

Relapsing fever—sometimes called bilious typhoid or famine fever—is much more infrequent in its incidence in this country than most of those already named. It has a noteworthy coincidence both as to time and place with typhus fever, and, like it, seems to be contingent upon privation and overcrowding. The causal factor is the *Spirillum Obermeieri*, which is so named after Obermeyer who first discovered it. It cannot be successfully inoculated in the lower animals except in the anthropoid apes. Relapsing fever has not visited this country in epidemic form since 1870–1871. It is both contagious and infectious. In some epidemics, notably the last, laundry-women who washed the clothing of those affected were seized with the disease. It would appear to confer but a passing immunity on those attacked.

Enteric Fever.—The causative organism of this disease is the *B. typhosus* which was discovered and isolated by Eberth. Much longer time has elapsed, however, since enteric fever, or typhoid fever as it was then called, was differentiated clinically from typhus fever. While the chief credit of establishing the clinical entities of these two diseases must, perhaps, be given to Sir William Jenner, it must not be forgotten that the claim must historically be divided between Jenner and two Glasgow physicians, Dr Alexander P. Stewart, who afterwards settled in London, and Dr Perry, who remained in Glasgow. As we have worked out in detail the evidence in another writing it need not be detailed here.[1]

The *B. typhosus* is a long thin rod, actively motile, has about ten flagella which are long and wavy in character, and is stained readily with ordinary stains. When the organism invades the human body, its elect seat of main activity is the intestinal tract, but it may, however, invade the pulmonary tract and give rise to a form of pneumonia. The latter form of invasion is usually signalised in individual or single cases, but in one Glasgow epidemic the true character of the disease was obscured at the commencement by the general prevalence of lung-symptoms in those attacked.

The incubation-period of the disease is between twelve and twenty days. The infective material is mainly shed from the body by the intestinal excretions, and the period of infectivity in any case is, therefore, determined by the length of time during which the bacillus is to be found in the stools. In certain cases this may cover a considerable period of time.

There have been, as yet, relatively few observations respecting the time after the onset of an attack when bacilli appear in the dejecta. Those of Drigaloki are, therefore, of some value. After examining sixty-four cases in which the commencement of the disease could be determined with some certainty, that observer found that in ten cases the bacilli appeared in the fæces during the first five days, in fifteen cases, between the sixth, and tenth day, in twenty-one cases between the eleventh and twentieth day, in eight cases during the fourth week, in seven cases from the fifth to the tenth week, and in three cases they persisted up till three months after attack.

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[1] *Trans. Philosoph. Soc. Glasgow*, 1886. *The Epidemic History of Glasgow*, 1783–1883.

Various observers as Kutscher, Curschmann, Schottmüller, Busquet, and others have proved the presence of the bacillus in the blood of patients within the first seven days of the illness and throughout the entire febrile stage of the illness.

The organism may also, in rarer cases perhaps, remain in the urinary tract, producing the condition known as bacilluria.

Bacilluria is due to the formation in the kidney of small capillary infarcts and inflammatory areas. Owing to the rapid breakdown of tissue in these small areas, the bacilli escape into the urine. Bacilli are not filtered through the kidney structure with the urine. Sometimes bacilluria is more associated with a cystitis than with a chronic nephritis.

Since the *B. coli communis* of Escherich is a constant inhabitant of the intestine, and is commonly found in excretally-polluted foods and liquids, and, besides, is morphologically and culturally not unlike the *B. typhosus* in some respects, it is important that these two organisms should be carefully differentiated.

The chief differential tests which are now relied upon are the following :—

	B. coli communis	*B. typhosus*
Morphology	Short rods, hardly longer than broad, but variable in size, and indistinguishable, in some strains, from *B. typhosus*.	Long thin rods, but variable in size in different strains.
Motility	Usually feebly motile ; but some strains are actively motile.	Actively motile.
Flagella	In number 5, 6, 8 or more ; short ; stain with difficulty.	In number usually about 10 ; long and wavy ; stain easily.
Gelatin "shake" cultures	Usually give abundant *gas* production, though not invariably.	No gas formation.
Litmus-milk cultures	Marked by acid with firm clot in most strains ; others, however, fail to clot milk and are only slightly acid ; some do not produce acid.	Slightly acid ; no clotting.
Neutral-red media.	Produces greenish-yellow fluorescence ; some strains fail to do so.	Red colour unchanged.
Gelatin, agar, and other media.	Rapid and luxuriant growth.	Slow and less luxuriant growth.

	B. coli communis	*B. typhosus*
Potato medium	Fawn or brownish-coloured growth, usually luxuriant; some strains produce a transparent growth.	Transparent, colourless growth.
Proskauer and Capaldi media, I. and II.	On medium I. grows with acid production. On medium II. grows, but no acid production.	On medium I. little or no growth. On medium II. grows with acid production.
Indol in Broth	Produces indol usually; some strains fail to do so.	Does not produce indol.
Pfeiffer's Test	Serum of a typhoid-immunised animal does not protect against inoculation of a lethal dose.	Does protect.
Serum Test.	Commonly negative; but some strains give a positive result.	Commonly positive.
Nutrose-lactose-litmus-crystal violet-agar medium (Drigalski - Conradi medium).	Produces in 24–36 hours at 37° C. *red* colonies due to acid production.	Produces violet - blue colonies.

Sources of Infection.—It has already been shown that water-supplies polluted with specific excretal matters give rise to outbreaks of enteric fever of varying intensity and extent (*vide* p. 176), and nothing is better established than that milk similarly contaminated will produce like results. In Glasgow alone, for example, during the past thirty years or thereby, almost every epidemic outbreak of this disease has been traced to infected in-brought milk from outside farms or dairies. This is, perhaps, equally true of other places. Shellfish raised in sewage-polluted waters also give rise to limited outbreaks. Conn in 1894 first drew attention to this.[1] Many others have done so since. Much work, indeed, has been done in this branch of the subject by different observers at home and abroad, and inquiries have been instituted at the instance of the Local Government Board of this country. Among the workers in this country may be named Klein, Cartwright, Boyce, Herdman, Bruce Low, Timbrel Bulstrode, Wood, Nash and others, and Netter and others abroad. Klein's reports to the Fishmongers' Company respecting the vitality of *B. typhosus* in oysters, mussels, and cockles, confirm the observations of Herdman and Boyce that the oyster can retain the living organism for some days, but that the organism does not multiply in the mollusc and eventually dies out; and that typhoid-infected oysters will rid themselves of the organism in about six days, if they are kept in frequently changed sea-water. Cockles are more dangerous, in respect that they take up a larger number of organisms relative to their size and do not, like the oyster, possess the power of devitalising the organism. A limited outbreak of enteric fever developed in Glasgow in 1908, due to mussels and whelks, among persons who had gathered the polluted shellfish in a sewage-polluted arm of the sea, and had eaten them after having brought them home.

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[1] *New York Med. Record,* 1894.

There can be little doubt, also, that the disease may be spread by specifically polluted dust, and by the agency of foul-feeding insects, such as flies. It is not improbable that to these causes is largely attributable the relatively greater prevalence of enteric fever in privy-midden towns in which scavenging and cleansing are imperfectly or inefficiently carried out, Attention to the transmissibility of this and like diseases in this country by the agency of insects has been stimulated by the knowledge gained of late years respecting the parts played by insects abroad in the transmission of diseases. The domestic house-fly, the blue-bottle fly, and others are, however, but passive carriers of contamination on their antennæ and legs. That they are capable of so conveying infective material from one substance to another has been demonstrated by experiment by different observers. In camps, the two foregoing factors, as well as polluted water and food, have played in the past an important part in the propagation of this disease and also dysentery, as, for example, in the South African War, and in army camps in the United States of America. It is most probable that this is largely due to the position of latrines and the faulty disposal of excremental matter. In the army camps assembled in selected sites in Virginia, Georgia, and other places in the United States of America during the Spanish-American War of 1898, of 107,933 officers and men in 92 regiments there were attacked with enteric fever between May and September no fewer than 20,738 persons, or nearly one-fifth of the whole force, of whom 1,580 persons or 14·63 per 1000 died. Investigation of 1608 individual cases showed that of that number 563 or 35·10 per cent. were directly connectable attacks, *i.e.*, occurred in same tents, and the 447 or 27·79 per cent. were indirectly connectable attacks, *i.e.*, occurred in next tents.[1] This evidence points to direct infection from person to person being more common under certain circumstances than has hitherto been believed.

On the other hand, at the Assouan Barrage Works, Egypt, where in 1898 there was encamped a mean number of 923 Europeans and 5463 natives in one large camp, not a single case of enteric fever originated locally during two years, although during that period on nine occasions was the disease imported from outside; and there was not a single death from it. These facts are all the more noteworthy because twelve years before, in 1886, there was encamped, on the very same site, a force of the British army about twice as large in numbers, of whom 276 were seized with enteric fever. This outbreak of 1886 was attributed to air-borne dust and the local insanitary conditions inseparable from camps. The freedom from the disease in the Barrage camp is believed to be due to the greater care exercised in the latrine-arrangements and disposal of the excreta, since the air-borne dust conditions must be reckoned as the same in both cases.

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[1] Reports by Drs Reed, Vaughan, and Shakespeare, "On Origin and Spread of Typhoid Fever during the Spanish War, 1898." Washington, 1900.

The question of dust-originated enteric fever raises the question of the vitality of the *B. typhosus* in soils. On this subject the results of different experimenters and observers are somewhat conflicting, possibly arising from want of parallelism in conditions of experiment or other circumstances. Martin, in his report to the English Local Government Board, stated that the typhoid organism remained alive for long periods in sterilised cultivated soils, but that it quickly died out in sterilised virgin soils; that in unsterilised soils, or artificially contaminated soils, when regard was paid to temperature and moisture, the organism could be isolated up to twelve days. Robertson of Sheffield concluded from his experiments that the organism could live for long periods in certain soils, and that it could grow to the surface when planted at a depth of eighteen inches. According to Koch, the bacilli may persist in manure throughout a winter. Dealing with an outbreak of enteric fever in Gelsenkirchen in 1901, Emmerich and Wolter[1] found that in soil much contaminated with human and animal excreta, the typhoid bacillus could not only live for months, but under favourable conditions may even multiply. Pfuhl[2] was able to isolate the bacillus from different infected soils as follows: (1) from moist garden earth after 88 days; (2) from dry sand after 28 days; (3) from moist peat, 21 days; and (4) from dried linen after 97 days. Firth's results, published before these of Pfuhl, corresponded closely: they were 74, 25, 13 and 74 days respectively. The chief differentiating culture-medium used by Pfuhl was the Drigalski-Conradi medium, and by Firth, litmus-glucose-agar of definite alkalinity. Germano[3] pulverised, sifted, and sterilised samples of house-dust, sand, humus, peat, etc., and saturated them with bouillon-cultures of *B. typhosus*, the liquid parts of agar-cultures, or actual typhoid fæces. The first set of samples were placed in open vessels in the air, and in these the bacilli were found to have died in those treated with the bouillon culture in 24 hours, and in those treated with the excreta six days. Another set was placed in a moist incubating chamber, and in all of these the bacilli were active after 60 days. Portions of clothing were steeped in typhoid excreta and placed in open vessels in the air of a room. Linen and cotton were found at the end of 60 days to have retained their infectivity, and flannel at the end of 90 days. As exemplifying the vitality of *B. typhosus* in soiled woollen articles, the following facts are important. In April 1903, enteric fever broke out among the boys on the training ship *Cornwall*. A lot of blankets had shortly before this been bought for the ship. It was observed that some of these bore marks of having been soiled. Some of these were submitted to Klein for bacteriological examination, and he found the stains to be swarming with the typhoid organism. On inquiry it was found that the bought blankets were part of a consignment which had been returned from the South African War to the Army Stores, and which had been sold. The question of the origin of enteric fever from sewer-gas, sewer-air, and ground-air is still doubtful. British experiments on the air of sewers do not seem to warrant the belief that such a cause is common, but Alessi's experiments on rats, guinea-pigs, and rabbits exposed to sewer air and gases, point to an inimical influence therefrom. It would probably be nearer the truth to say that exposure to such atmospheres lowers the bodily vitality, and renders those so exposed to be more susceptible to infection when it offers. Ground-air from polluted infected soils must be supposed under favourable circumstances to be liable to carry the organism, but the subject must still be held to be *sub judice*.

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[1] *Die Entstehungsursachen der Gelsenkirchener Typhus-Epidemie von* 1901, Munich.

[2] *Zeits. f. Hyg.*, Bd. xl., Ht. 3, p. 555.

[3] *Ibid.*, xxiv., p. 3.

Foods of different kinds, which have been exposed to contamination by dust or by insects, have been known to spread the disease. Milk is, perhaps, the chief of these, but fried fish has been reported by Hamer as the cause of limited outbreaks in Southwark, Lambeth, and Kensal Green, London, in September, 1900.

Water-cresses grown in sewage-polluted water have also been blamed with propagating the disease. The action of wines on *B. typhosus* has been studied by Sabrazès and Marcandier.[1] Generally speaking, they found that ordinary wines exercised a distinctly bactericidal effect on that organism ; that white wines were more potent in this direction than red wines ; that champagne destroys the organism in less than ten minutes : that of the red wines Beaune is the most effective, but only after exposures of about thirty minutes, and that this bactericidal power does not seem to depend upon the percentage of alcohol in the wines tested, which varied from 8 per cent. to 15 per cent., but rather upon the degree of acidity of the wines. When a white wine found to be distinctly acid was rendered neutral, the bacillus which was then killed was now able to live. White wines are more likely to show acidity—hyperacidity—than red wines, the former, in addition to organic acids, containing small variable amounts of free sulphuric acid.

Infected mangles, doubtless due to imperfectly-washed infected clothing, have been held by Priestley to be the cause of a limited outbreak in Lambeth, London, in 1900.

Typhoid "Carriers."—Certain anomalous circumstances in the causation of repetitive sporadic cases, and, indeed, of small explosions of enteric fever, led gradually to the suspicion that it might not be improbable that otherwise seemingly healthy persons might be the unconscious hosts of the typhoid-bacillus and propagators of the disease. It was known that in certain cases after recovery from the clinical symptoms of an attack, the typhoid-organism persisted in the urinary tract and was to be found in the urine in the affection known as bacilluria. Horton Smith in 1897 [2] had drawn attention to the presence of the bacillus in the urine of enteric-fever patients during the clinical manifestations of the disease. Further investigation by him showed that the organism was nearly always to be found in pure culture under those circumstances, and that occasionally 1 c.c. of urine might contain as many as five hundred millions of organisms. If, then, the bacillus may persist in the urine, why not also in the intestinal tract, and, therefore, in the fæces ? Attention was first drawn by German observers to the fact that certain persons were actually the harbourers of the organism, and by their intestinal dejecta were the unconscious distributors of enteric fever. Of these observers may be named Kayser, Klinger, Nieter and Liefmann, Levy, Friedel, Dehler and others. Kayser's case of the female baker in Strassburg [1] is now classical. In the bakery, of which this woman was the owner and employer, it had been noted that every new employee was sooner or later seized with symptoms resembling enteric fever, from which, indeed, some of them had died. Suspicion fell on this woman's condition, and on her fæces being examined they were found to contain typhoid bacilli in large numbers. Her blood was found to respond to Widal's test in dilution up to 1 : 100. The same observer isolated another "carrier" in a woman engaged in the milk-trade, arising out of an investigation concerning a milk-produced epidemic.[2] It is noteworthy that in the case of a third carrier, who had had enteric fever about thirty years before, her illness was complicated by jaundice. Nieter and Liefmann isolated seven "carriers" in a lunatic asylum of 250 patients in 1906.[3] Friedel found a "carrier" in another asylum in 1907.[4]

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[1] *Ann. de l'Inst. Pasteur*, April 25, 1907.

[2] *Med. Chir. Trans. London*, 1897.

So far as the German investigations have gone, it would seem as if asylums were a fruitful source of "carriers" of the disease.

It was not long before similar discoveries were made in this country. In Glasgow and neighbourhood, an epidemic of enteric fever broke out early in December 1907, and continued into the third week of January 1908, in which 139 persons (115 in Glasgow, 21 in Partick and 13 who sickened after leaving Glasgow) were attacked. Of the 126 local cases, 8 died. The attack rate was between 4 and 5 per cent., and the case-fatality rate was 5·5 per cent. Investigation traced its connection with a particular milk-supply. On 20th December, the persons employed in connection with a county dairy-farm, one of the sources of supply to the suspected dairy, were examined. One person was found ill. She had been confined to bed from 10th December, and was being medically attended by a doctor, who first saw her on 12th December, and believed her to be suffering from influenza. Through some misunderstanding, a sample of her blood was not obtained for examination until 24th December, and it was accompanied by the information that her illness was pneumonia of the right lung. Her blood, however, gave a good positive reaction with the Widal test. She was removed to the County Hospital. Although this case might reasonably be associated as the cause of the outbreak which culminated about 11th January, it could not account for the cases prior to 14th December. The question therefore arose: Did the case of this woman, as well as the earlier cases, arise from a hitherto unsuspected "carrier" case? Dr R. M. Buchanan, the bacteriologist of the city of Glasgow, set about a bacteriological examination of the milk-utensils, drains, etc., at the farm for evidence of the typhoid-bacillus, but with a negative result. He thereupon turned his attention to the milkers. In the end, it was discovered that one elderly woman, so employed, had suffered along with her family from enteric fever sixteen years before. She was sent into hospital in order that reliable specimens of her dejecta might be obtained for bacteriological examination. The typhoid organism was found in the fæces. Her blood gave a positive Widal reaction.[1]

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[1] *Arb. a. d. Kaiserl. Gesundh.*, Bd. xxiv., p. 176.

[2] *Ibid.*, p. 173 ; *ibid.*, Bd. xxv., p. 223.

[3] *Münch. med. Woch.*, 1906, p. 1611 ; *ibid.*, 1907, p. 1622.

[4] *Zeitschr. f. med. Beamte*, No. 6, 1907. *Vide* also: Dehler, *Münch. med. Woch.*, Nos. 16 and 43, 1907 ; Klinger, *Arb. a. d. Kaiserl. Gesundh.*, Bd. xxiv., p. 91.

Drs A. and J. C. G. Ledingham have reported that a certain lunatic asylum in Scotland had, since 1893, been the centre of a succession of small outbreaks of enteric fever. Inquiry regarding the usual sources of the infection proved negative. In September 1907, they began a systematic bacteriological examination of the stools of the patients. From the main building, samples of the fæces of 57 female patients were first examined. In the dejecta of one of these—a woman who had been in the asylum since 1896—typhoid bacilli were found in enormous numbers. It was not known that she ever had had an attack of enteric fever. She was isolated. A new case of enteric fever, however, showed itself. The dejecta of 34 female patients who were domiciled in another part of the asylum were next examined, and in the fæces of one of them —a woman aged 61, who had had enteric fever in 1895, and who had been continuously in the asylum since that year—abundant typhoid bacilli were found. In addition to these, a third woman, aged 30, who had had enteric fever in 1904, was also discovered to be a "carrier."[2]

Dr Branthwaite, H. M. Inspector for England under the Inebriates Acts, has reported an outbreak of enteric fever in an Inebriate Reformatory. The first case occurred in September 1906, and between that time and November 1907, twenty-eight persons were attacked, of whom two died. These cases occurred in batches of three, four, and five, each batch sickening at the same time. They occurred at irregular intervals. The only clue indicated the milk-supply as the cause. Three officers of the institution, who lived and got their food outside, but who got their milk from the institution, were attacked. Officers who were supplied with undiluted milk suffered in greater proportion than the inmates who only had their milk in hot tea or cocoa. The milk in the institution was sterilised before distribution, and had so been prior to the first outbreak. Inquiry showed no reason to believe that this was not being properly done. It was concluded, therefore, that contamination must have taken place after the sterilisation process. Dr Davies, medical officer of health of Bristol, then began to look out for a human "carrier." One dairymaid, who had had enteric fever six years before, was found whose blood gave a semi-positive Widal reaction. The typhoid bacillus was found in her fæces. She was immediately excluded from all dairy work, and up till three months after her exclusion no new cases had arisen. On inquiry as to her duties, it was found that the outbreaks began after she had been admitted to kitchen work, but they became more frequent after her work became exclusively confined to the dairy. Infective excreta were found to be passed only intermittingly.[3]

Dean has recorded the facts of the case of a medical practitioner, who, twenty-nine years before, when a young man, contracted enteric fever while resident in America. Since his original illness he had been the victim of repeated attacks of biliary colic, sometimes accompanied by jaundice. His fæces were found to contain *B. typhosus*, and his blood gave a positive response to Widal's test in 1 : 25. So far as is known, it does not appear that he had been the cause of the disease to any around him.[1]

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[1] *Report of Med. Off. of Health for* 1907.

[2] *B.M.J.*, vol. i., 1908, p. 15.

[3] *Report on Inebriates Acts*, 1908 ; *B.M.J.*, vol. i., 1908, p. 701.

Drs Findlay and R. M. Buchanan of Glasgow narrate the case of a woman, 51 years of age, who 25 years before had had enteric fever. She suffered from distended gall-bladder. Her blood was positive to Widal's test in 1 : 50 within an hour. Cholecystotomy was performed, pus and gall-stones being removed. *B. typhosus* was isolated in pure culture from the pus at time of operation, the organism being also found in the fæces. Sixteen days after the operation, the bacilli were as numerous in the discharge from the gall-bladder as in the pus at time of operation. They were not got rid of, indeed, until after three weeks' further daily douching of the gall-bladder with 1 : 40 carbolic acid. She died nine weeks after the operation from sudden cardiac failure.[2]

There are two features of these "carrier" cases which are noteworthy as well as interesting. The first of these is that, up till now, the majority of them have been women, and the second, the recurring history of biliary symptoms during the enteric fever attack and periodic continuance of these long after apparent recovery from the fever. Jaundice, as a complication of enteric fever, while far from being common, cannot be said to be rare. Ogilvie [3] has drawn attention to the occurrence of jaundice as a symptom common to several cases in an epidemic outbreak, and to the literature of the subject. The conjunction of such a history of jaundice and the after discovery of such persons as "carriers" would almost indicate that, where jaundice is a concurrent symptom or an early sequel of enteric fever, special attention should be paid to the bacteriological examination of the fæces.

Widal's Reaction or Serum Diagnosis of Enteric Fever.—The serum of the blood may, under certain conditions, acquire the property of agglutinating, agglomerating, grouping, or clumping some particular organism when mixed with a culture of that organism. Such happens in the serum of a person suffering from an infective disease toward the micro-organism which is causative of the disease. To test whether the blood of any such person possesses this agglutinating or clumping property, it is only necessary to expose a fresh culture of the organism believed to be causative of the disease to the serum of a small portion of the blood taken from the person, in certain dilutions and for certain definite times, and to watch microscopically the results. After the mixture of serum and microbic culture has been made on a slide, what is desired to be discovered microscopically is, whether the contained organisms continue uniformly distributed throughout the mixture or are thrown into groups or clumps, and, if the latter, in what time, and, second, if the organisms be motile, whether the mobility continues or whether it ceases. It will be observed that in Widal's test there are two phenomena—viz. (*a*) agglutination, and (*b*) bactericidal effect.

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[1] *B.M.J.*, vol. i., 1908, p. 562.

[2] *B.M.J.*, vol. i., 1906, p. 385. *Vide* also: Soper, *Jour. Amer. Med Assoc.*, vol. xlviii., p. 2019.

[3] *B.M.J.*, vol. i., 1901. p. 75.

Modus operandi.—Blood for the test may be obtained by pricking the ear of the person, after the skin has been well washed with a mixture of alcohol and ether. It is then drawn into a Wright's blood-capsule or into capillary tubes which have been carefully washed and sterilised; thereafter the ends are sealed in the flame. On standing in the tubes, the blood will separate into serum and coagulum, and the former alone is used for the test. But the serum requires to be diluted, the dilutions usually made being 1 : 10, 1 : 20, 1 : 50, and 1 : 100, but they may be made to extend downwards to 1 : 5000 or even 1 : 10,000, although these last two dilutions are seldom used. Where very small amounts of serum are being dealt with, these dilutions are commonly made by means of a platinum wire loop. A handy way to make a dilution of, say 1 : 10, is to dot nine loopfuls of bouillon separately around the imaginary centre of a small circle and then in the centre to add one loopful of the serum. By mixing the whole together, the desired dilution is obtained. From this the greater dilutions may easily be made. Control dilutions must be made with normal serum in the same way. A bouillon culture of *B. typhosus* not more than 24 hours old, and incubated for that time at 37° C., is the standard test-culture used. In order to apply the test microscopically, equal quantities of the dilution of serum, and of the bouillon-culture of the organism are mixed together, and a hanging-drop or like preparation is made of the mixture. Examination under the microscope is to discover whether the organisms show any evidence of lessening and vanishing motility, and whether clumping takes place, together with the time of clumping. Note would also be taken of the strength of the dilution relative to the time. It is a good plan to note also (1) the strongest concentration and (2) the weakest dilution of the serum which will produce agglutination or clumping. With respect to the lengths of time within which the phenomenon of clumping is observable, it may be taken generally that these will depend on the degrees of dilution of serum employed, the rule being that the greater the dilution the longer time required for a complete reaction to take place; indeed, under weak dilutions there is a risk that the reaction will be incomplete, no matter the time of exposure. The standard dilution used and the gauge of time of reaction are respectively 1 : 30 and half an hour. If complete clumping takes place under these conditions, the diagnosis that the blood has been derived from a person who is suffering or has suffered from enteric fever is as reasonably certain as may be. With greater dilutions and longer exposures and incomplete reactions, the diagnosis should be given most guardedly. While in certain exceptional cases Widal's reaction may be obtained with the blood of an enteric-fever patient as early as the third or fourth day of the disease, it is, as a rule, most reliable when found at the end of the first week or thereby of the illness, while it will continue throughout the entire illness, through convalescence, and for a varyingly long period after the person has apparently resumed normal health. In addition to the blood, any serous effusion in the body, or even the bile or milk of a person, and in a minor degree the urine, will respond to Widal's test. It has already been observed that in the Widal test are two distinct phenomena—viz. agglutination, and death of bacilli. These properties do not seem to be possessed by one and the same constituent of the serum, because the bactericidal power may be destroyed by exposing the serum to a temperature of 55° C. for half an hour, while the agglutinative power is not thereby destroyed or changed.

For diagnostic purposes, when properly carried out and when proper inference from results is made, the value of Widal's reaction is considerable. Probably it will be near the mark to say that in about 95 per cent. of cases of enteric fever the response will be definitely positive. At the same time, possible error may arise from the fact that the disease from which a person is suffering may not be enteric fever and yet his serum will give a positive reaction with *B. typhosus*, and, in a few odd cases, the disease may be enteric fever and the serum fail to give a response.

Antityphoid Inoculation or Vaccination.—The only personally applicable prophylactic measure of recent times with regard to this disease is Pasteurian vaccination or inoculation. Wright and Semple have been identified with the practical carrying out of the technique of the process as well as with its inception. The organisms used for the purpose are of such virulence that one-fourth of a 24 hours old agar-slope culture when injected hypodermically into a guinea-pig of 350–400 grammes in weight will kill the animal. If such a culture be emulsified in broth, and the organisms therein then be killed by heating at 60° C. for five minutes, the material for injection is obtained. When used for vaccination, a quantity of the dead culture varying from one-twentieth to one-fourth of the original amount is injected hypodermically into the body of the person, usually in the flank. The effects are—(*a*) locally: tenderness around point of injection with, perhaps, a little swelling and tenderness of adjacent lymphatic glands; and (*b*) constitutionally: a rise of temperature of two or more degrees, and a sense of restlessness—all of which usually pass off within 24–36 hours. The blood of a person so inoculated responds well to Widal's reaction, thereby indicating that some measure of immunity has been conferred. The protective inoculation has now been used on a sufficiently large scale to test its value; for example, of over 4000 soldiers in India so vaccinated only 0·98 per cent. contracted enteric fever afterwards, while of over 25,000 in the same stations but uninoculated, 2·54 per cent. fell victims.[1] It is said that longer and more effective protection against attack is conferred if a second operation is performed about ten days after the first. There seems to be little doubt of the prophylactic value of the inoculation, if it be carried out in persons shortly before they are about to be exposed to the disease.

Bassenge and Mayer hold the view [2] that the reaction which follows the injection of dead typhoid-bacilli is not due solely or entirely to specific substances contained in the material inoculated, but is also partly the result of the products of metabolism of the bacilli and other substances. Founding on the discovery of Brieger and Mayer that after living typhoid-bacilli have been shaken in sterile distilled water, and filtered germ-free, the filtrate had a high immunising value, Bassenge and Mayer experimented on the applicability of this to man. The material employed by them for inoculation is a clear, watery, yellow-coloured, slightly-opalescent fluid. A single injection of 2–5 c.c. gives rise to elevation of temperature, and the effect of one such injection on the blood-serum of the person injected is such that one milligramme of the serum, taken from the body fourteen days after injection, when inoculated into a guinea-pig of about 200 grammes weight, could protect the animal against a dose of the typhoid-organism from fifteen to thirty times over the usual lethal dose. Besides, the agglutinating power of the serum rose considerably though not parallel to the bactericidal power, which was greater. The protective power of the serum was found to continue for several months. Further experience of this remedy will, doubtless, determine its merits.

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[1] "A Short Treatise on Antityphoid Inoculation," Wright, 1904.

[2] *Deut. med. Woch.*, May 4, 1905.

Dysentery.—This disease is endemic in many parts of the world, and may become epidemic among new settlers in any one of these. While it would be difficult perhaps to make grades of distinction regarding its prevalence in different parts of the globe, most observers seem to be agreed that it is especially prevalent in the West Indies, India, the Malay Archipelago, and Southern China. It is one of the oldest known of classical diseases. Epidemic dysentery does not seem to have prevailed in Great Britain, although it has been mentioned by Sydenham in the epidemic in London in 1669, and again by Baker in 1762. Outbreaks of a disease, akin in character and symptoms to dysentery, sometimes called asylum dysentery or muco-colitis, are far from rare in this country. Indeed in 1904, in the Report of the Lunacy Commissioners for England, it is stated that outbreaks occurred in no fewer than 88 county and borough asylums involving 1016 patients of whom 254 died. Not a few who observed these outbreaks have reached the opinion that they are in no way different from tropical dysentery. In Lyons, in 1904, 67 cases of the disease appeared among the soldiers of the garrison.[1]

The causative organisms of the disease are (1) *Entamœba hystolytica* (Schaudinn), (2) Shiga's bacillus, (3) *B. dysenteriæ* (Flexner), and (4) the pseudo-dysentery organism of Kruse.

Dopter, who has made an elaborate study of the disease from the bacteriological side,[2] points out that in the serum of animals vaccinated against the bacillus of dysentery, and in the serum of persons infected with dysentery of bacillary origin, a specific fixative substance is found which may be demonstrated. In the latter, it may be found in the serum by the end of the first week of illness, and to persist throughout convalescence. It is independent of agglutinative power. This fixative is not found in amœbic dysentery. Both in animals and in man, a serum rendered specific by one kind of dysenteric bacillus is capable of acting as a fixative to other dysentery-producing bacilli; thus the Shiga bacillus, the Flexner bacillus, and the pseudo-bacillus of Kruse exhibit in this respect an identical reaction. Dopter is of opinion that this fact has an important bearing on the possible differences in etiological significance of the so-called types of dysentery bacilli. While the Shiga and the Flexner types are distinguishable by their difference in agglutinative reactions and by cultural differences, he believes, owing to the production in common of this specific fixative substance, they are biologically identified, and that these "types" are not specifically distinct organisms in the sense that they are capable of setting up different types of dysenteric disease. Any differences they may possess are akin to the differences found, for example, in different strains of cholera vibrios.[1]

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[1] Braun, Roussel, and Job, *Lyons Méd.*, Jan. 1, 1905.

[2] *Ann. de l'Inst. Pasteur*, Dec. 1905.

Smallpox.—The quest for the *causa causans* of variola has been long and arduous, and remains still in the region of speculation notwithstanding the laborious researches of many experimenters of many countries. It is, without doubt, contained in variolous matter, and in a modified form in vaccinal lymph.

So far back as in 1868, Chauveau and Burdon Sanderson were able to show that if solid particles of lymph were separated by filtration or sedimentation, they retained the power of producing vaccinia, while the filtered fluid did not possess that property. In 1872, Cohn believed he had discovered the organism, to which he gave the name of *Microsphæra variolæ*, Klebs in 1873, another organism, which he called *Tetracoccus vacciniæ*, and Guarnieri, in 1892, still another, which he named *Cytoryctes vacciniæ*. Korté, still later, discovered an organism, an amœboid protozoon which measured about $\frac{1}{2500}$ of an inch in diameter, was of an oblate-sphaeroid form, contained intra-cellular spores, and was actively amœboid in the form found in human vaccine lymph. To this he gave the provisional name of *Amœba variolæ vel vacciniæ*. He found the extra-cellular spores of the parasite in variola and in human vaccine to be motile at body-temperature, shortly after their removal from the pock, but in glycerinated calf-lymph both the organism and its spores had lost their motility due to inhibition by the glycerine. Ballah was able to corroborate the presence of these organisms, which have been described as spherical bodies of diverse sizes up to that of a red blood-corpuscle or even larger, the appearance of which suggested sporulation. For a time, Ballah thought that he had secured a method of growing these from test-tube to test-tube, but in the end became convinced that they were neither specific, nor, indeed, were living matter. Funck concluded from his observations that vaccinia is due to a protozoon infection, the name which he gave to the organism being *Sporidium vaccinale*. The view that a protozoon is the causative organism has gained ground by the researches of Councilman and Calkin. These observers discovered appearances in the cell protoplasm of the pock of small, homogeneously-staining, structureless bodies, about 1 μ in diameter which did not stain so deeply as nuclei, and which gradually developed in size within the cells as their containing cells degenerate. During this period of growth, small granules surrounded by circles appear in these bodies, their general outline becoming more and more irregular until ultimately they grow more and more like amœbæ. At this stage, these amœboid forms break up into smaller spore-like bodies. This constitutes the first cycle of life of the organism. At this point, the nuclei of the epithelial cells begin to exhibit alterations in structure. They appear to be penetrated by the small spore-like bodies, and then ring-shaped bodies appear in them. These increase in size, and then become surrounded by sponge-like bodies which grow, filling the nuclei, and finally destroying them, the bodies being liberated. These bodies again become homogeneous ring-shaped structures, each possessing a central dot. These final bodies these observers deem to be the specific or infective agent.[1] Thus far have observations gone. Time and further research, however, are required for verification, and, if well founded, for their cultivation *in vitro.*

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[1] *Cf.* Ruffer and Wilmore, *B.M.J.*, vol. ii., 1909, p. 862.

The comparatively recent exhaustive work of the Royal Commission on Vaccination, whose final report was issued in 1896, is still fresh in the mind. It is unnecessary here to do more than emphasise their final conclusions in a few sentences.

There is no substitute for vaccination, say the Commissioners, but a complete system of notification of smallpox, immediate hospital isolation of those attacked, and isolation and daily observation of contacts are valuable auxiliaries toward the repression of smallpox. No considerable number of smallpox patients should ever be treated together in any hospital which is situated in a populous neighbourhood, and ambulance arrangements relative thereto should be organised and supervised with most scrupulous care. Neglect of such precautions would seriously neutralise the benefits of the measures described, in face of a population partially unvaccinated or imperfectly vaccinated primarily or by lapse of time since primary vaccination. Calf-lymph only should be employed, and should be supplied by the State. While the Commissioners were fully alive to the great value of revaccination, and while desirous of encouraging the practice in every way, they were deterred by the difficulties which confronted them to recommend that it should be made compulsory.

It is not necessary here to adduce statistics to show that the disappearance of smallpox has been in direct ratio to the prevalence of the practice and efficiency of vaccination and revaccination in any part of the world. These may readily be obtained by consulting the volumes of evidence put before the Commission. It is, perhaps, enough to say that Germany, in which vaccination and revaccination are both compulsory, during the twelve years 1891–1902 with a population of 56,000,000, had only 607 deaths from smallpox, while Great Britain with a population of 32,000,000 had, during the like period, 6,761 deaths.

The proposition above stated—viz. that smallpox ceases to prevail in direct proportion to the prevalence of efficient vaccination and revaccination, may readily be proved by a rapid survey of the vaccination history of some of the chief countries of Europe and elsewhere.

In France, vaccination during the first year of life became compulsory in February, 1902, as did also revaccination between the ages of eleven and twenty-one. Calf-lymph is used, three vesicles being required for successful vaccination. Neglect or refusal of vaccination is followed by penalties. No conscientious objections are permitted. All conscripts entering the services, all students entering university schools, and all officers entering Government employment must produce certificates of recent successful revaccination. The Minister of the Interior supervises the vaccination of the country.

In Germany, vaccination was permissive until 1874, when it became compulsory between the first and second year of life, and had to be repeated in the thirteenth year unless the child in the interval had had smallpox, or had been revaccinated within five years preceding that age. The operation of vaccination is free of cost to all, and is performed by district public vaccinators who use calf-lymph supplied at the expense of the district authorities. Germany has 25 State institutions for supplying lymph. Each Confederate State makes and carries out its own regulations as to vaccination and revaccination. Schoolmasters in charge of children are responsible till vaccination has been carried out, and must send notice to the authorities of all scholars unvaccinated, under a penalty. Parents and guardians are liable to penalties for non-compliance with the law. A public vaccinator is liable to a fine or imprisonment for negligence or inefficiency in the performance of his duty. Previous to 1874, the mortality from smallpox was a mean rate of 309 per million living, but since that year, the rate has only been 2 per million living. Indeed, it may be said that smallpox has been practically eradicated from Germany.

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[1] *Boston Med. and Surg. Jour.*, Ap. 30, 1903.

In Austria regulations as to vaccination began in 1808, but from that year till 1900 there was no compulsory enforcement. At the same time, indirect compulsion was in operation, since public authorities, schoolmasters, and others were bound to encourage the practice. Persons entering schools, public institutions, and the army must be vaccinated primarily or be revaccinated, but children cannot be refused admittance to primary schools if parents refuse that they be vaccinated. Smallpox prevails more in Austria than in Germany, but from 1895–1900 there were only seven deaths from that disease recorded in Vienna.

Vaccination was introduced into Russia in 1801. The Empress of Russia was vaccinated at that time, and she insisted on the general adoption of the practice. It is, however, not compulsory generally, but it is so for entrants to schools, universities, and civil and military service. Generally speaking, Russia is a poorly-vaccinated country, and smallpox epidemics are relatively common.

In Denmark, vaccination began in 1802, and was made compulsory in 1810. The operation may be performed, however, at any time before the completion of the sixth year. State-supplied calf-lymph only is used. Those who do not comply with the law are fined, and conscientious objections are not listened to. Revaccination is obligatory on soldiers, and all inmates of public charitable institutions. Denmark is a well-vaccinated country.

The Netherlands do not make vaccination obligatory, but schoolmasters and scholars must produce certificates before admission to school that they have been vaccinated or have had smallpox, and all soldiers and prisoners are revaccinated. Although not compulsory, vaccination generally prevails.

In Italy, vaccination within six months of birth has been compulsory since December 1888. Revaccination is compulsory on entrants to schools or official life. The law is carried out rigorously. As a whole, Italy is a well-vaccinated country, the mortality from smallpox having declined from 610 per million living in 1888 to 9·7 per million in 1900.

In Switzerland, practice as to vaccination is not uniform. In sixteen cantons it is obligatory, in nine others it is discretionary. The age of operation is from two to five years. Revaccination is general in the majority of cantons, and entrance to public schools or into official life is forbidden unless entrants have been recently revaccinated. Vaccination in that country is controlled by the sanitary authorities. In Norway, vaccination is not compulsory, but all heads of schools or educational institutions (other than primary schools) are held responsible for the admission of unvaccinated pupils. All entrants to the army and navy, all those admitted to their first communion, and all those about to marry, must produce evidence of having been vaccinated, no personal objection being considered. It is estimated that 80 per cent. of the total population are vaccinated. From 1890–1900, there were only thirty-two deaths from smallpox in the country.

Sweden makes vaccination obligatory before the end of the second year, or a fine is imposed. Six or eight vesicles are required. No child is admitted to school or to any public establishment without proof of vaccination. Soldiers who join the army must be revaccinated. It is a well-vaccinated country, the mortality from smallpox in 1900 being about 2 per million living, but previous to the institution of compulsory vaccination the mortality was nearer 2000 per million living.

In the United States of America, only a few of the States have passed any law regarding vaccination, the practice being, however, largely followed by large numbers of citizens. Smallpox prevails more or less in the States. During the year ending 30th June 1902, there were 55,857 cases of smallpox with 1852 deaths, or a fatality-rate of 3·31 per cent., whereas in 1901, the total cases numbered 38,506 with 689 deaths or 1·79 per cent.

In Canada, also, a similar state of matters prevails; in some provinces only has any vaccination-law been passed, but the practice largely prevails. Provincial governments and municipal authorities possess the power, however, to make vaccination compulsory in times of threatened epidemics of smallpox.

Neither is there any uniform practice in our Colonies and Dependencies. In India, the Act of 1880 gave power to prohibit and stop inoculation, and made vaccination obligatory in certain areas, municipalities and cantonments. Therein, all unvaccinated children having arrived at the age of six months during the vaccination season must be vaccinated forthwith, unless the operation be postponed by certificate. Neglect to vaccinate a child is reported by the superintendent of vaccination to the district magistrate who orders immediate vaccination, and if disobeyed, may impose a fine, and if still disobeyed, may impose a very heavy fine or a term of imprisonment. Of the Australian States, vaccination is compulsory in Victoria within six months of birth, and the operation must be performed three successive times, if failure follows the two preceding, before a certificate of immunity may be given or accepted. Prior to 1900, for thirteen years there had not been a single death recorded from smallpox. In Western Australia and in Tasmania, the law generally is the same, but the period of primary vaccination may be extended until twelve months after birth. Conscientious objection is a valid ground of refusal. In New South Wales there are no vaccination laws, and obligatory vaccination, therefore, does not prevail. Smallpox is rare in this State, only three deaths having been recorded in the decade 1890–1900. In Queensland, vaccination is regulated by the Public Health Act of 1900, by which power is given to make vaccination obligatory in any area in which the provisions of the Act are in force.

In New Zealand, vaccination is compulsory within twelve months of birth, but within four months after the birth of a child a parent can obtain a certificate of conscientious objection; otherwise, if primary vaccination be evaded after the first year of life, the parent or guardian may be summoned and an order to vaccinate made, which, if disobeyed, will be followed by a fine, but only one conviction is legal until the child attains the age of four years, when legal action may again be taken. The number of vaccinations has greatly decreased during late years since conscientious objection has been permitted to prevail. All pupils in public schools, inmates of prisons and other penal establishments, as well as of hospitals, must be vaccinated or revaccinated, in the latter case, where the operation has not been performed within the five years preceding.

In Cape Colony and Natal, the Public Health Act of 1897 made vaccination obligatory within three months after birth. No conscientious objection is allowed by the law. Failure to comply with the law is followed by monetary penalty.

The history of Great Britain and Ireland relative to vaccination is briefly as follows :—

England.—The National Vaccine Establishment in London was founded by Royal Warrant in 1807, and the first Vaccination Act was passed in July 1840, in which Act also it was made a penal offence to inoculate variolous matter. This Act of 1840, however, did not make vaccination obligatory. In 1853, an Act was passed which made it compulsory that all infants within three months of birth should be vaccinated with human lymph. By the Act of 1867, powers were given to Local Authorities to pay vaccinators. Then followed the Acts of 1871 and 1874, and still later the Act of 1898. Only the provisions of the Act of 1898 demand attention. Its provisions came into operation on 1st January, 1899. The period within which a child must be vaccinated was changed from three months to six months after birth, thereby repealing section 16 of the Act of 1867, and if the parent or guardian of any child so requires, the public vaccinator is to visit the child at the house of the parent or guardian for the purpose of vaccinating, instead of the child, as in the Act of 1867, having to be brought to the public vaccination-station. The Act further provides that if a child is not vaccinated within four months after birth, the public vaccinator, after at least 24 hours' notice to the parent or guardian, shall visit the house of the child, and shall offer to vaccinate the child with calf-lymph or such other lymph as may be issued by the Local Government Board. The Local Government Board issued the Vaccination Order of 1898 which dealt with this point as follows :—If the vaccination-officer has not received in respect of any child a certificate under section 2 of the Act of 1898 within the time limited by that section, and at the end of seven days after the expiration of six calendar months from the birth of the child, has not received any other of the certificates mentioned in sub-division (*a*) of this paragraph (that is, of unfitness or of immunity), the vaccination-officer shall forthwith give a notice in the Form K set out in the fifth schedule to this order or to the like effect to the parent or other person having the custody of the child, by delivering the same by post or otherwise at the last known residence of such parent or person. If that notice is not duly complied with within the time specified therein, it will become the duty of the vaccination-officer under the Vaccination Act, 1871, to take proceedings for the enforcement of the law.

The Act further instituted what is now known as the "conscientious objector." No parent or other person, says the Act, shall be liable to any penalty under section 29 or section 31 of the Vaccination Act of 1867, if within *four months* from the birth of the child he satisfies two justices or a stipendiary or metropolitan police magistrate in petty sessions, that he *conscientiously believes* that vaccination would be prejudicial to the health of the child, and within seven days thereafter delivers to the vaccination-officer a certificate by such justices or magistrate of such conscientious objection.

The Act of 1898 further provides that an order under section 31 of the Act of 1867 directing that a child be vaccinated shall not be made on any person who has previously been convicted of non-compliance with a like order relating to the same child. Any persons committed to prison under this Act shall be treated as first-class misdemeanants.

Scotland.—The Vaccination (Scotland) Act of 1848 made vaccination legal and optional and prohibited inoculation, and the further Act of 1863 made vaccination compulsory. The age-limit of primary vaccination in Scotland has always been within six months after birth, but the time might be postponed on the ground of unfitness of the child from ill-health. Parish Councils alone appoint public vaccinators. The Registrar-General and the Local Government Board jointly administer the Act. By this Act, there was no legal exemption from obligatory vaccination of a child by its parent or guardian, and parish councils might exercise discretion as to how frequently they might prosecute an offender for non-compliance. By the passing, however, of the Vaccination (Scotland) Act, 1907, it is enacted that no parent or other person shall be liable to any penalty under section 17 or section 18 of the Act of 1863, if within six months from the birth of the child he makes a statutory declaration that he *conscientiously believes* that vaccination would be prejudicial to the health of the child, and within seven days thereafter delivers the declaration to the registrar of the district in which such child was born and registered. A registrar to whom such a declaration is duly delivered shall not, so far as regards the child named therein, carry out the procedure as to intimation and transmission prescribed by the said sections in respect of the failure to transmit to him the certificate in those sections mentioned. Each registrar shall keep such a record of statutory declarations as may be prescribed by the Registrar-General, and shall furnish to any Local Authority executing the Public Health (Scotland) Act, 1897, within his district, such periodical returns of such declarations as may be required of him, and approved by the Local Government Board, for each of which declarations the Local Authority shall pay him the sum of two pence, and shall provide him with the forms on which such returns are to be made and pay for their transmission by letter post. Registrars are to allow searches to be made in such record of statutory declarations, and, on demand, shall give a certified copy of any entry therein on payment of the fee for the search and certificate prescribed by section 15 of the Vaccination (Scotland) Act, 1863.

The statutory declaration, according to the form prescribed in the schedule to the Act of 1907, must be made and signed by the declarant before a justice of the peace, a magistrate, or a judge ordinary, who shall certify and sign that the declaration was made before him.

Ireland.—The Vaccination (Ireland) Act, 1840, enacted voluntary gratuitous vaccination, and the Act of 1863 made it obligatory, while the Act of 1876 enacted gratuitous revaccination. Vaccination must be performed within three months after birth. There is no exemption-clause in the Irish Acts.

The institution by the Legislature of the Conscience Clause, which was in consonance with the views of the Royal Commission on Vaccination, is calculated to act in a retrograde fashion if it increases the number of conscientious objectors to vaccination in England and Scotland, but if, as was intended, it breaks down opposition by prohibiting repeated prosecutions of a parent for non-compliance with the law, as was formerly the case, it may, after all, tend to promote vaccination among those whose attitude towards vaccination was more one of mere neglect or indifference than of reasned oobjection. From a Parliamentary paper, of date 6th August 1900, it appears that the number of children in England respecting whom certificates of conscientious objection had been received from the date of passing of the Act of 1898 (that is, from August to the end of 1898) was 203,213, while during the year 1899, only 32,357 had been similarly exempted.

The total births registered in 1898 was 923,265, and in 1899, 928,640, the total certificates of successful vaccination numbered 500,314 in 1898, and 669,349 in 1899, or 52·4 per cent. and 72·1 per cent. respectively of the births registered, being an increase in ratio of 33 per cent. in 1899 as compared with 1898. So far as these returns go, they would seem to justify the view of the Commission [1] that it would conduce to increased vaccination if a scheme could be devised whereby the attempt to compel those who were honestly opposed to vaccination could be stopped, and to get those children vaccinated whose non-vaccination had hitherto been due to the mere negligence or indifference of parents.

View the conscientious objector, however, as we may, the effect of his non-compliance with vaccination maintains a population scattered throughout the country readily vulnerable to the attack of smallpox, and, so long as revaccination is not generally practised by enactment, which contributes to the spread of milder forms of the disease among those whose primary vaccination has either been originally inefficient or has been long antecedent to time of exposure.

The economic effect of an efficient system of vaccination and revaccination with regard to expenditure and upkeep of smallpox hospitals is well exemplified in the case of Germany. According to the report of Dr Bruce Low to the English Local Government Board respecting the arrangements made in Germany for the isolation of smallpox cases, the special smallpox hospital does not there exist. The only hospital in Germany devoted to smallpox which he found was one in Mainz, which had been erected in 1892 in the grounds of a nursery gardener, and which had never had a single case of smallpox within its walls. It is only necessary to contrast with that the situation in Great Britain, in which about £4,000,000 have been spent in the erection and upkeep of hospitals devoted to smallpox. In the London area alone, no fewer than 2500 hospital beds have to be maintained in readiness against possible outbreaks of smallpox. According to the majority of observers, the very institution of a smallpox hospital, even in a well-secluded locality, becomes a menace to the neighbouring population under certain circumstances (*vide postea*). These precise circumstances are, however, still a matter of debate. Some maintain that the congregation within one building of a large number of cases produces such intensity of infection that the infection may be conveyed aerially even for distances up to three miles. Others affirm, on the other hand, that careful analysis of the facts concerning outbreaks of disease in populations living in the neighbourhood of hospitals reveals the existence of the more obvious explanation of immediate or mediate infection. The reasons for such a conclusion are these: in the first place, and perhaps mainly, the hospital during an epidemic of smallpox is the centre of a large amount of traffic: ambulance traffic to and from, visits of friends and relatives of those afflicted to inquiry-rooms and to wards, it may be, under certain precautions to see friends or relatives whose lives are in danger, leakages of various kinds from the hospital through the agency of the staff, workmen, tradesmen, cleaners and others, under circumstances of imperfect supervision or from infringement of hospital regulations. Owing to the fallibility of all human rules and of the power of observing them, even the best hospital regulations break down more or less under stress of epidemic circumstances, and more especially when all the resources of a hospital are being taxed to breaking-point, and when the hospital, moreover, is likely to be overcrowded. Such facts as these emerge in a critical survey of such epidemics as Fulham, Sheffield, Warrington, Leicester, Orsett, and other places, concerning which the aerial-convection theory has been invoked to account for the spread of the disease. From such a study we have arrived at the conclusion that the aerial-convection theory is not proved.[1]

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[1] *Final Report,* par. 524.

Calf-Lymph.—It will, perhaps, be true to say that in most countries in which vaccination is obligatory, calf-lymph is now most generally employed. Some knowledge of its preparation ought to be possessed by the student of public health. Healthy calves only are employed. When the vesicles are mature, the lymph-pulp obtained therefrom is first weighed, and is then passed through a triturating machine which consists of a continuous screw with a diminishing worm which revolves in a closely-fitting cylinder. All parts of the machine have been previously sterilised by prolonged exposure to steam. The effect of the machine is to reduce the pulp to very fine particles. The pulp is now gradually mixed with four times its weight of a sterilised mixture of 50 per cent. pure glycerine and distilled water, but the precise amount of dilution depends upon the original quality of the lymph. The pulp, now mixed with some of the glycerine-water mixture, is again passed through the machine, the remainder of the mixture being added during its passage, and, finally, the resulting mixture is once more passed through, the ultimate product being a fine and homogeneous emulsion. This emulsion is now put into sterilised tubes holding from 4 c.c. to 10 c.c., each tube being filled as full as will enable it to be plugged with a sterilised cork without admixture with air. The cork is sealed with melted paraffin rendered aseptic with carbolic acid. The tubes are then placed in a cool cupboard or an ice-chest. The lymph is now bacteriologically examined, agar-agar plates being the medium and apparatus used. The plates are incubated for seven days, for the first 24 hours at blood-heat and for the remaining six days at ordinary room temperature. Colonies which develop are counted and examined. This process is repeated week by week, the effect steadily being a diminishing number of developing colonies. This is due to the combined effect of the glycerine and the heat. Experience has shown that the higher the temperature at which the lymph is incubated, the more rapid and marked is the diminution in the number of colonies; and the lower the temperature the reverse. The greatest diminution of extraneous organisms occurs during the first week. The original number of such organisms found in any particular batch of lymph varies, but usually they are completely eliminated by the end of the fourth week. Among the extraneous organisms which have been found are the following :—

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[1] "Smallpox Infection from Hospitals," *Jour. San. Inst.*, vol. xxv., Part II., 1904, pp. 218–269.

Staphy. aureus and *albus*, *B. mesentericus*, *Proteus vulgaris*, but no strictly anaerobic organisms are found. Neither streptococci nor *B. tuberculosis* have ever been found. Of the above-named organisms, *B. mesentericus* is the most difficult to eradicate. When the lymph has become germ-free, samples of it are drawn into sterilised capillary tubes by a machine, and these are sent to the animal Vaccine Establishments to be used in the vaccination of children. The results of these vaccinations are recorded a week later, and from the number and size of vesicles obtained the potency of the lymph is estimated. When thus proved to be satisfactory, the remainder of the batch is transferred into sterilised capillary tubes, each tube being sufficient for one vaccination, the tubes are sealed at the flame, and thereafter are deposited and stored in an ice-chest to be despatched as required to the National Vaccine Establishment at Whitehall. During an average year, lymph sufficient for about a million vaccinations is issued.

Lymph, so kept, may remain potent for about a year, longer or shorter, but its working potency is reckoned ordinarily as of two months duration.[1] From experiments made by Blaxall and Fremlin on the effects on the lymph of temperatures below freezing-point, it has been proved that there is no loss of potency even after an exposure to a temperature of 180° C. below freezing-point for a considerable time, and that there is no diminution in potency even after having been kept for a year in a cold store at -5° C. But the lymph quickly becomes inert in tropical climates, and even at summer temperature in northern regions. Calmette and Guérin obtained the best development of vaccine on animals kept in an atmosphere of 18° to 20° C. Carini[2] found vaccine emulsion to be almost inert after exposure for thirteen days to a temperature of 37° C.

Cholera, in this and most other countries, is essentially an epidemic disease, although in certain countries as India, it is endemic. It causes a high mortality. In many outbreaks the line of infectivity could be tracked by trade-routes, or by intercommunication between an infected and a non-infected people. It is more prevalent in the warmer seasons of the year; but to this general rule there are marked exceptions. Great Britain and Ireland have been subject to outbreaks of it on four different occasions—viz. in 1831, 1848, 1853 and 1866, with, in addition, a very limited outbreak in 1893.

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[1] Blaxall, *B.M.J.*, vol. ii., 1902, p. 37.

[2] *Centralb. f. Bakt.* (orig.) xli., 1906, p. 32.

The epidemic of 1831 had its origin in an infected ship which arrived in Sunderland from Hamburg in October 1831, from which it rapidly spread through the country. It broke out in Glasgow on 12th February 1832, and before it disappeared, it was estimated to have seized one in every six families of the population, and to have caused one death in every thirteen families. The total number of deaths was 3166, of which 1419 were males and 1747 were females. The total number of cases known to the authorities up till November 5 of that year was 6208, or 1 in 32½ of the entire population. The mortality was chiefly confined to the intemperate, the dissolute, the ill-fed, and ill-clothed part of the population, but it did not overlook the better-conditioned classes. It attained its maximum in August.[1] The total mortality in England from this epidemic, according to Hirsch, was 30,924 deaths. The epidemic of 1848 began after the arrival of an infected ship from Hamburg at Hull in October of that year. It quickly spread to London, Edinburgh, and other places, and arrived in Glasgow in November 11. The last case reported in Glasgow was on March 22, 1849. The epidemic, therefore, lasted in that city for four months and eight days. The number of deaths was 3923. This epidemic, unlike the former, attacked chiefly the better classes. The total mortality in England was estimated at 53,293. The outbreak of 1853 also came from Germany, several English sea-ports being almost simultaneously attacked. It appeared in London in August, and in Glasgow about the middle of December, and continued in the latter city more or less for a whole year. It culminated in the month of August. The total deaths in Glasgow, so far as known, was 3885, of which no fewer than 1023 occurred in August. The total deaths in England and Wales was estimated at 20,097. The seizure of 1865–1866 was much more limited both in numbers attacked and in mortality. It was imported originally to Southampton from the Mediterranean in July. It reached Glasgow in 1866, and the number of deaths in that city only amounted to 53. The total mortality in England and Wales was 14,378. The outbreak of 1893 was limited to a few sea-port towns on the south-east coast of England. The number of cases was small.

During 1905–1906 epidemic cholera slumbered in Russia, and in April of the latter year the Russian Government summoned a medical conference in Moscow to consider means for checking the spread of the epidemic. In the previous October there had been an outburst of the disease at Kerman in Persia, and it was suspected that the importation of the disease into Russia was in some way connected therewith. In Russia it spread along the river Vistula, broke out in a convict-prison and in a garrison-town on its banks. Two cases occurred at Hamburg. Down to Sept. 5 of 1905, 99 cases with 26 deaths were reported within the German Empire, no fewer than sixteen districts having been declared infected. The Local Government Boards of this country issued warning letters to port and riparian Sanitary Authorities, owing to which special precautions were taken to prevent the entrance of the disease. It is satisfactory to note that these measures were successful. Bruce has reported the facts of the outbreak of cholera in Malta in 1887.[2]

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[1] *Vide* paper on "The Epidemic History of Glasgow 1783–1883," by the Author, *Proc. Philosoph. Soc. of Glasg.*, vol. for 1885–1886.

[2] *Lancet*, vol. i., 1898, p. 433.

The freedom of this country from outbreaks during the last 20–30 years must be attributed mainly to better water-supplies and improved sanitation, since the facilities of intercommunication with other countries in which it is endemic or epidemic have become enormously multiplied. Cholera is essentially a water-borne disease. This is well illustrated in the Hamburg outbreak (*vide postea*). The infective matter is almost solely confined to the intestinal discharges. Stools, therefore, must be thoroughly disinfected, or preferably, cremated after admixture with sawdust. There can be no doubt that its causal factor is the *B. choleræ Asiaticæ* which was discovered by Koch. The organism is of the form of a slightly curved, slender rod with pointed end, not unlike the comma of German type, hence its more common name, *B. kommæ*. It probably would be more correct to describe it as a vibrio, which forms the segment of a spirillum. The vibrio or spirillum is the shape assumed by the organism when three or more organisms are joined together end to end. It measures in length from $\frac{1}{8}$ to $\frac{1}{3}$ the diameter of an ordinary red blood-corpuscle. It can be easily cultivated aerobically on ordinary culture-media, but it is capable of growth under anaerobic conditions, from which it appears to gain virulency but to lose power of resistance to adverse conditions. It thrives abundantly in sewage and contaminated liquids, but dies after a few days when placed in pure water, doubtless from want of nutrient material. It is readily destroyed in acid media, therefore, under normal conditions of the stomach, it is destroyed by the acid gastric juice.

Influenza is a typical pandemic disease. During the last half-dozen centuries it has broken out and spread over entire continents. It has within the last few years ravaged the countries of the world. It was known to exist in Siberia in May 1889, and by the end of December of that year, every European country had been attacked; and within six months thereafter, most of the countries of the world.[1] It would appear to be uninfluenced by meteorological conditions, for it spreads with as much freedom in Iceland as at the Equator. While in not a few instances the line of infectivity may be tracked from place to place, and from country to country, in others it cannot be defined; but there is great reason to believe that like other infective diseases it is propagated by infective persons or infective things, and obeys the same natural laws. Whether or not there is a direct causal relationship between its outbreak in man and in animals, it is frequently coincident with the existence of a disease in horses called "pink-eye." This coincidence has so frequently been found that it would seem to point to a relationship between them, although the precise character of that relationship is not yet well understood. Influenza is both contagious and infectious. Like other infective diseases, its severity of type varies; in some epidemics, its original form is comparatively slight, but it gains in intensity during the progress of the outbreak. Pfeiffer has isolated a bacillus from the purulent bronchitic sputum of those attacked, which is generally believed to be its causal factor. It is a fine, short rod, having rounded ends, is frequently found in chains, and measures 0·5 micro-millimetre in length. It is easily stained with carbol-fuchsin. Much remains to be known regarding the habitat of this organism and the modes of its propagation.

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[1] *Vide* paper on "Influenza" by the Author, *San. Jour.*, April 1892.

So far as is known at present, it enters the body chiefly by the air-passages.

Whooping-Cough is commonly a disease of the early years of life, but is not unknown to attack those of maturer ages. The highest mortality obtains within the first five years of life. Of the total deaths from this disease, about 40 per cent. occur within the first year, about 70–75 per cent. within the second, and from 90–96 per cent. within the fifth year of life of those attacked. It is both contagious and infectious. The channel of attack is the air-passages, since its initial symptoms are those of catarrh of the upper mucous tract. The infective matter is chiefly centred in the bronchial and nasal secretion. This disease, along with measles, accounts for a higher mortality than all the other zymotic diseases put together, and not uncommonly one is the sequel of the other, since the mucous membrane left weakened by the one affords a suitable culture-ground for the micro-organism of the other. They have many times been known to run concurrently. It does not appear to have any strongly marked relationship to seasonal influences. The higher death-rates which obtain in certain seasons over others seem to be determined more by complications than by the influence of the disease itself, although various complicating diseases are engendered by the existence of whooping-cough. It may, however, be said generally, that the highest mortality prevails in the first three months of the year, and the lowest, in the summer months; but this is, doubtless, in large measure due to the pulmonary complications which are apt to arise in the more inclement conditions of the winter and spring months. Whether age confers a resisting power against the disease is a question difficult to determine. While it is well established that adult life is but rarely the subject of attack, it is a matter of some uncertainty whether this apparent immunity is not due to unrecognised attacks in infancy or childhood. If, however, an isolated community be attacked, the disease finds its victims in children and adults alike. In one island on the west coast of Scotland, for twenty years before 1892 the disease was unknown; but in that year it was introduced, and of a total population of 380 persons, 114 were attacked at all ages up to twenty. A micro-organism has been found in whooping-cough, but it is not yet clearly proved to be the intimate causal factor.

Within recent years there has been much bacteriological investigation concerning the causative organism of this disease. Zusch [1] described a short oval rod-bacillus, one and a half times as long as broad, the centre of which stained imperfectly. He had isolated it in twenty-five cases. Before it can be cultivated it must be completely freed of mucus. It grows best on glycerine agar with anasarcous fluid. Its colonies are moderately small, round, slightly raised, grey or greyish-white, and finely granular. It does not grow so well on ordinary agar, or glycerine agar, or glucose agar, nor any better on blood-serum agar than on glycerine agar. It does not liquefy gelatine nor produce any turbidity in broth after 24 hours, but a sediment is deposited. It is non-motile, forms no spores, is but slightly resistant to high temperatures, and is mostly Gram negative. It does not ferment grape-sugar, nor coagulate milk, not does it give a serum reaction. It agreed in most particulars with an organism previously isolated by Czaplewski, who, having examined Zusch's specimens, agreed that they were the organism he himself had isolated. Koplik also isolated an organism in thirteen cases out of sixteen of pertussis, which he described as a delicate short bacillus, thinner than *B. diphtheriæ* and not more than one-third or one-half its length, measuring 0·8 to 1·7 μ in length and about 0·3 μ to 0·4 μ in breadth. He believed this to be an organism similar to one isolated in this disease by Afanassiew. Vincenzi [1] also isolated a bacillus identical with that described by Jochmann and Krause as *B. pertussis Eppendorf*, but different from those found and believed to be characteristic by Czaplewski and Hensel and others. Among the most recent investigations on this subject are those of Bordet and Gengou,[2] which were carried out in the Pasteur Institute, Brussels. The organism isolated by them is a small bacterium, ovoid in form, which stains very feebly in its central parts with carbolised methylene-blue or toluidin, does not form spores, and is killed by a temperature of 55° C. It grows well on a medium composed of equal parts of defibrinated human blood and gelatin with some added glycerine and potato decoction. It does not grow on ordinary media. It differs from the organisms described by Afanassiew, Czaplewski, Vincenzi and others, in not being able to grow on ordinary culture-media. Bordet and Gengou believe their organisms to be the specific organism of whooping-cough for the following reasons: (1) that in children who never previously had any respiratory affection but who have been attacked by undoubted pertussis, the organisms are found plentifully in the leucocytic secretion on the fifth day; and (2) that the serum of children recently recovered from pertussis possesses a marked agglutinative power on the organism, and the serum of healthy persons or of those who have had pertussis years previously does not possess this property. If the foregoing researches teach any lesson, it is that there does not appear to be at present any agreement in common relative to the specific organism of whooping-cough.

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[1] *Münch. med. Woch.*, June 7, 1898; *B.M.J.*, vol. ii., 1898, pp. 20 *seq.*

As bearing upon the infectivity of a common cold, it has been observed of inhabitants of remote islands who are cut off from intercourse with the mainland for the major portion of each year, as in St Kilda and other islands similarly circumstanced, that whenever a ship visits the island, numbers of the inhabitants are seized with a catarrhal infection of the naso-bronchial tract, which, in St Kilda at least, is known as "the strangers' cold."

Diphtheria, a name given by Bretonneau in 1826 to a disease which was formerly called angina, and which was first described by Aretæus the Cappadocian about eighteen centuries ago, is due to a micro-organism which chiefly attacks the surface of the upper mucous membrane of the air-passages, or abraded skin-surfaces of other parts of the body. Its origin in microbic influence was first suggested by Laycock in 1858. A committee of the Royal Medical and Chirurgical Society of London, appointed to inquire into the nature and cause of diphtheria and membranous croup, reported in 1879 that while certain micro-organisms were found by them in false membrane, they did not regard them as causative agents. Oertel discovered a coccus which he considered to be the prime cause. Klebs in 1873 found a bacillus in the throat of affected persons, but he failed to isolate it by culture out of the body. Friedrich Löffler corroborated Klebs' discovery, and succeeded in isolating the organism by artificial cultivation. He also proved the existence of the coccus described by Oertel, but established by experiment that it was not causative of the disease. The *Bacillus diphtheriæ* has come, therefore, to be spoken of as the Klebs-Löffler bacillus. It is a long, straight, or slightly-curved, non-motile rod, which is thickened or clubbed at one or both ends, and which measures between 1·2 and 2 micro-millimetres in length. It stains readily by Gram's method. Associated with the Klebs-Löffler bacillus are the pseudo-diphtheritic bacillus of Löffler, which he found in 1887, and that of von Hoffmann, to which the latter drew attention in 1888. These exhibit, however, certain clinical and cultural differences from the true organism which enable them to be distinguished from the true bacillus. The researches of Hewlett and Knight have established the following points of difference. Clinically the pseudo-organisms, although found in certain cases of sore throat and membranous rhinitis, are not contagious, and the patches in which they are found do not tend to spread. Culturally, they may be distinguished by the following differences—viz. (1) On alkalised potato, they form distinctly visible, cream-coloured colonies in two days, whereas the growth of the true bacillus in the same time is almost invisible ; (2) With neutral litmus-agar they produce an alkaline reaction, the true bacillus, an acid reaction ; (3) In nutrient broth, under strictly anaerobic conditions, the pseudo-organisms do not grow, whereas the true bacillus grows freely ; (4) The former gives the indol-reaction with *peptone-water* only after three weeks' growth, the latter, at the end of one week. Other observers as Roux, Yersin, and others affirm, however, that the pseudo-bacilli are simply ordinary diphtheritic bacilli which have become attenuated in influence. Salter's observations go a long way to substantiate this latter view. By cultural treatment he succeeded in transforming the supposed non-pathogenic pseudo-bacillus into one having the pathogenic properties and morphological characters of the true bacillus, and which, when injected into guinea-pigs, operated exactly similarly to the true bacillus.[1]

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[1] *Centralb. f. Bakt.*, March 12, 1902; *B.M.J.*, vol. ii., 1902, pp. 12 *seq.*

[2] *Le Scalpel*, Sept. 2, 1906; *B.M.J.*, vol. ii., 1906, pp. 60 *seq.*

From the practical point of view, therefore, it is better to treat the pseudo-bacilli, when found in the living human body, as having the potentialities of the diphtheritic bacillus, until at least more regarding their life-history is known. Diphtheria mainly attacks the young, although it does not spare those of adult years. It attacks the female more than the male sex, and the death-rate of the former is the higher. It prevails more in rural than in urban communities, but it would appear to be on the increase in the latter ; but whether this is due to increased facilities of inter-communication, to school-life, on account of its presence not being detected early, or to drain-sources, or from those combined, has not yet been definitely determined. Whether the disease in fowls known as "gapes" or "roup" is identical with diphtheria is also undecided, but our observations show that the presence of a false membrane in these birds is sometimes followed by a paralysed condition of the lower limbs.

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[1] *Trans. Jenner Instit.*, series ii., pp. 113–125.

From the point of view of practical hygiene, it is of importance that the identity or non-identity of " gapes " or " roup " with diphtheria should be decided. Turner[1] has shown the existence of this fowl-disease and human diphtheria to be concurrent in several instances. He further affirms that he has seen a farmer's wife, her son, and a daughter seized with a disease notified by a medical practitioner as diphtheria, from treating fowls which were suffering from the disease called " gapes " or " roup " or " sincup " all of which are local names for the same disease ; that he has succeeded in conveying human diphtheria to fowls ; and that he has seen paralysis of the lower limbs of a fowl succeed the throat-affection. We can personally corroborate the last observation.

Ferré[2] has also given some attention to the subject. He believes the diphtheria or " pip " of birds to be closely allied to the disease in the human subject. Some forms in birds are due to the Löffler bacillus, some to *B. coli communis*, and some to the pneumo-bacillus, the first being the most virulent. He narrates the case of a child who suffered from diphtheria, proved by bacteriological examination, and who recovered after treatment with antidiphtheritic serum. This child had been playing with a cock near a henhouse, this bird having had " pip " about two weeks before. The bird was then still somewhat hoarse on crowing, and was also slightly paralysed. Complete paralysis supervened later, and the bird died. On its body being dissected, patches of membrane were found in the larynx, and a number of hard yellow nodules, known to be found in bird-diphtheria, were discovered in the intestine. Cultures were made from these, and a bacillus similar to Löffler's bacillus isolated, which, when inoculated into pigeons and guinea-pigs, caused diphtheria and death. In a further series of experiments, healthy fowls were inoculated with a toxin prepared from culture of this bacillus, and paralysis was produced, which was cured by the use of antidiphtheritic serum. He also found that fowls which suffered from " pip " were much benefited by the administration of that serum.

The identity of the disease is, on the other hand, denied by M'Fadyen and others. But all this points to the need for definite experimental evidence.

Diphtheria does, however, attack cats, and these animals are readily affected by taking milk containing a culture of the organism. In December, 1905, an outbreak due to cats was recorded in the Burgh of Govan by the medical officer of health. One of the cats examined was found to be suffering from post-diphtheritic paralysis of the legs, and swabs taken from the throats of two others were found to contain organisms culturally and otherwise identical with the *B. diphtheriæ*. There can be little doubt, however, that the main cause of spread of the disease is school-life, owing to the use in common of slates, and the too prevalent habit of children of cleaning the same with their saliva. There are reasons also for believing that it may be associated with certain ulcerated conditions of the udder of the cow. The experiments of Klein, which consisted in injecting a culture of the organism into the body of the cow, demonstrate that swelling and thickening follows at the point of injection; that it increases for about seven days, and then subsides; that broncho-pneumonia develops, which is followed by a vesicular eruption on udder and teats, the fluid of which contains the bacillus; and that the milk of the cow, when given to cats, gives rise to an illness which exhibits great likeness to that which is sometimes found in cats during epidemics of human diphtheria.

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[1] *B.M.J.*, vol. i., 1900, p. 1900 ; *idem*, p. 1506.

[2] *Arch. clinique de Bordeaux*, June 1897.

While diphtheria usually manifests itself in epidemic form, in certain districts it is endemic, and sporadic cases may also arise. The time of greatest mortality is in November and December, which accords with the time of greatest prevalence of epidemics of the disease; the lowest-mortality period is the summer months. Atmospheric humidity, rainfall, wet condition of soil, and other factors have been indicated as predisposing conditions to its outbreak and prevalence, but no satisfactory evidence has yet been adduced in proof. The infective matter, apart from contagion from the sick, is believed to be carried, and the disease therefore to be propagated, by air and milk, and some would add, by water. There is no proof, however, of the truth of the last. In respect of milk which has been exposed during its preparation for sale to infective matter from a sufferer, or which has been handled by a carrier or distributor who is suffering from a mild attack of the disease, the bacillus finds a suitable culture-medium in which to grow; consequently, many outbreaks have been traced to this cause. In its growth in the human air-passages, the bacillus forms albumoses or toxins which on absorption into the blood produce profound changes in the nervous system, of which paralysis of the palate, and even paresis of one half of the body, are not uncommon manifestations.[1] The membrane or exudation is occasionally found on parts of the body other than the throat. We have seen two instances in which it had developed on abraded surfaces on infants in houses in which another member of the family exhibited it in the throat. Coiffii has reported a case of utero-vaginal diphtheria during the puerperal period,[2] and O'Brien, of diphtheria of the glans penis after circumcision.[3] Croup is a name associated with certain symptoms of difficult, noisy, crowing respiration, which is due to laryngitis accompanied by more or less tumefaction of the laryngeal mucous membrane. But diphtheria is sometimes mistaken for croup when the location of the false membrane is laryngeal, by reason of the mechanical difficulty of respiration thereby produced. Membranous croup is not in public health law held to be a synonym for diphtheria, as it is named separately in the schedule of the Notification Act. That such membranous exudations may arise on the laryngeal mucous surface there is no doubt, as, for example, where strong ammonia vapours are inhaled; but in view of the aid to diagnosis which bacterioscopy affords, the time has arrived when the name membranous croup should be blotted out of public health nomenclature.

Erysipelas, the prime factor of which is the *Streptococcus erysipelatis*, is one of the few zymotic diseases which does not by one attack confer immunity against a second, or even a third attack. The same organism has probably to do with the genesis of puerperal fever. The incidence of erysipelas is upon the skin of exposed parts of the body, due to the entrance of the organism by a breach of surface, which may be very small. It is met with all over the world, and occasionally assumes epidemic proportions. Being closely allied with scarlet fever and puerperal fever, it is found to be coexistent at the times and seasons when these prevail. It attacks by preference the male sex, but this is probably due simply to the fact that males are more exposed to conditions calculated to produce abrasions of the skin. It is most fatal in the winter months. While it once was common in hospital practice, it has practically ceased to exist therein since antiseptic and aseptic precautions began to prevail. The infective matter is chiefly found in the area of skin-tissue affected. Phlegmonous erysipelas, which manifests itself by extensive and rapid destruction of areolar tissue accompanied by suppuration, is due to what is commonly known as the *Streptococcus pyogenes*, which, according to recent observers, is identical with the *S. erysipelatis*, their apparent differences in action being, probably, largely owing to the nature of the tissue invaded, and in some measure also, to the type of virulency of the organism.

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[1] *Vide* paper by author, *Proc. Phil. Soc. Glasg.*, March 1895, "The Antitoxin Treatment of Diphtheria."

[2] *Rif. Med.*, Nov. 22–24, 1899; *B.M.J.*, vol. i., 1900, pp. 11 *seq.*

[3] *B.M.J.*, vol. ii., 1907, p. 908.

Puerperal fever is a communicable disease associated with parturient women. It is a somewhat unfortunate name, since in modern nosology it is used to include a variety of conditions. It ought to be distinguished by one feature—viz. septic poisoning. It is caused by the *S. pyogenes*. Its infective character is most marked. The infective material clings tenaciously to the clothing and person of attendants, hence the most scrupulous care and completeness should characterise the disinfection of everything and of every person in connection with a case. It has been propagated by medical men and nurses from the sick to the healthy, notwithstanding the most vigilant care and most thorough disinfection. It may arise from the air of house-drains ; at least, certain cases point strongly to this source. Careful aseptic toilet of the patient, absolute cleanliness of hands and instruments, and good sanitary surroundings will prevent its inception and check its spread. While the designation "puerperal fever" is found in the Infectious Disease (Notification) Act, 1899, it is to be remembered that, for death-registration purposes, that designation ought no longer to be employed, but instead such terms as "puerperal septicæmia" or "puerperal sapræmia," or "puerperal pyæmia," as the case may be.[1]

In order to protect infant life at the time of birth, and, doubtless, with the intention to reduce the mortality of mothers during the puerperium from puerperal septic diseases, the Midwives Act, 1902, was passed. The Act does not, however, extend to Scotland or Ireland. Its main provisions are as follow :—After April 1st, 1905, any woman, who not being certified under this Act to take or use the name or title of midwife either alone or in any other combined name, so takes any such name implying that she is a person specially qualified to practise midwifery, shall be liable to a penalty ; and any woman who habitually, and for gain, shall after that date attend women in childbirth, except under the direction of a qualified medical practitioner, and who is not certified under this Act, shall also be liable to a penalty. To be certified under the Act, a woman had to show that within two years of the passing of the Act she held a certificate in midwifery, and had been for one year at least in *bona fide* practice as a midwife. A Central Midwives Board was appointed for the purpose of regulating, *inter alia*, their own proceedings, issuing certificates and conditions of admission to the roll of midwives, course of training and conduct of examinations, regulating, supervising, and restricting the practice of midwives, and deciding the conditions of suspension of midwives from practice. Every Council of a county or county borough shall be the local supervising authority over midwives within their respective areas, and such Council shall investigate charges of malpractice, negligence, or misconduct on the part of any midwife within their area and report the same to the Central Board, shall suspend any midwife, if such suspension appears necessary, in order to prevent the spread of infection, and shall report to the Central Board the name of any midwife under their supervision convicted of an offence. Any woman, duly certified under this Act, who proposes to commence practice as a midwife in any area, before commencing so to do shall give notice in writing to that effect to the local supervising authority.

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[1] *Vide* Williams, "Deaths in childbed ; a Preventable Mortality," London, 1904.

Pneumonia must be reckoned, in one of its forms at least, as a zymotic disease. By reason of its outbreak in epidemic form from time to time in this and other countries, its microbic origin was suspected. Pathology has demonstrated that the form which the disease then assumed was what is known as the croupous or fibrinous form, and that the croupous inflammation very often was confined to the upper lobe. Moreover, clinically it differed from the catarrhal form in the symptoms exhibited. But the diagnosis is rendered very difficult by the fact that marked pulmonary symptoms may initiate other microbic invasions of the body. This is true of anthrax, plague, and sometimes of enteric fever. In one very extensive and fatal outbreak of enteric fever in Glasgow due to infected milk, many of the earliest cases had so pronounced pulmonary symptoms that the true nature of the disease was masked for a period; but as the cases progressed, it became clear and conclusive. The highest mortality from pneumonia is attained in December, but it is also high during the other winter months. An epidemic of this disease prevailed in Middlesborough in the first half of 1888, attacking 1633 persons in a population of 97,000, of whom 369 persons died. This is the largest epidemic which has occurred in this country. Ballard reported that this arose from meat-poisoning by American bacon, the most prominent symptom being pneumonia.[1] According to Foulerton,[2] epidemic pneumonia again prevailed in the same town in 1900–1901, this time characterised by fibrinous lobar attacks, which, however, were not due to pneumococcus infection, but in his opinion, which was derived from bacteriological investigation, to a bacillus possessing all the characters of the *B. coli communis*, to which, according to Klein and Ballard, the epidemic of 1888 was also attributable. In 1882, Friedländer and Talamon discovered in croupous pneumonia a definite micro-organism which they called the *Bacillus pneumoniæ*

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[1] *Local Government Board, Supplementary Report*, 1887 and 1888.

[2] *B.M.J.*, vol. ii., 1901, p. 760.

Friedländer, and pure cultures of which injected into rabbits produced the disease. Further observations, however, showed that that organism played but a secondary part in the genesis of pneumonia, and that the true micro-organism was the pneumococcus discovered by Talamon-Fränkel. This organism is actually a diplococcus, and has been called by a variety of names, as, for example, *Diplococcus pneumoniæ* of Weichselbaum, *Streptococcus lanceolatus* of Talamon and Gamaleia, and the micrococcus of Sternberg. In the Middlesborough epidemic, Klein found a bacillus in the tissues of those who had died of the disease, to which he gave the name of *B. pneumoniæ*. The *Diplococcus pneumoniæ* forms pairs of cocci, which are found grouped not unlike streptoccoci, hence the difference in nomenclature. The cocci have a distinct, lanceolate shape at each extremity, as seen in bodily fluids, but this character is lost in artificial culture. Moveover, in tissues they are enclosed in a capsule, or what appears to be a capsule, which is also lost by artificial cultivation. It is easily stained by Gram's method, whereas the organism of Friedländer is decolorised. But in respect of pneumonia generally, there are strong grounds for believing that the disease is altogether due to microbic influences. It may be that there is more than one causal factor; that is, indeed, more than likely: but the exact answer can only be given by further and more intimate study of the disease from the bacteriological standpoint. According to a report of Dr Reynolds, Health Commissioner of Chicago (1902), pneumonia has been proved to be a highly infectious disease. Since June, 1900, pneumonia claimed as its victims in Chicago more than one-eighth of all the deaths, one-third more than from consumption, and 46 per cent. more than all the deaths from the other contagious and infectious diseases combined which numbered 4489, while the number from pneumonia was 6582 deaths. Parsons made a report to the English Local Government Board of a small epidemic outbreak in Scotter, Lincolnshire, in 1890. There were 29 cases and 18 deaths. Mice fed with bread soaked in the sputum of the sick—fourth day of the disease—almost immediately died. Klein found in the bodies of the dead mice a bacillus identical with the organism found in the Middlesborough outbreak. In the Scotter outbreak, multiple cases in the same house were rare. Of the 29 persons attacked, 16 were over 55 years. Parsons attributed the cause to sewer infection.

Plague.—This disease, which in the earlier centuries overran continents and destroyed millions of lives, and which last appeared with epidemic force in this country in 1665, again made its appearance in the autumn of 1900. While, however, it has been absent for so long a period from this country, it has in the interval on more than one occasion visited the continents of Europe and Asia. It is noteworthy that these outbreaks, recent and remote, have all had their origin in the East; indeed, it is believed that it is endemic in certain districts of Upper India, Southern China, Manchuria, and in Persia and Turkestan.

The Justinian outbreak in the sixth century, which worked havoc in Great Britain between the years 664 and 685, and the Black Death, which spread from Asia to Europe, appeared in Italy in 1348, in England in August, and in London in November of that year, left enormous deathtolls in their wake. It is estimated that the latter, in Europe alone, destroyed no fewer than twenty-five million persons. Becoming endemic in Great Britain and Europe between the fourteenth and seventeenth centuries, it did not become extinct in the former till some fourteen or fifteen years after the Great Plague in London in 1665. Disappearing practically from Europe for the most part of the eighteenth, it was only to be found in limited areas during the nineteenth century, and vanished from the Continent in 1844. In 1853 it appeared in Western Arabia; in 1858 Tripoli was attacked; and in 1863 a fatal outbreak of the bubonic type developed in Persian Kurdestan. In 1867 it broke out among the inhabitants of the marshy lands of the Southern Euphrates, having, doubtless, been conveyed thither by pilgrims. In 1871 it again revisited Persian Kurdestan, and in 1874, the Lower Euphrates, Tripoli, and Assyr, within four days' march of Mecca; while during 1875 and 1876 it lingered in the Euphrates valley and Bagdad. In 1884 the disease existed in Yunnan, China, and at Pakhoi, near Tonkin. In March, 1894, it appeared in Canton, and by May it had reached Hong Kong. From thence it spread to India, appearing in the Bombay Presidency in 1896, and in Calcutta in April 1898. In 1896, four cases appeared on three British ships sailing from Bombay and Calcutta; in 1897, two lascars took ill on board the *Carthage*, four and twelve days respectively after leaving Bombay, and in 1898, certain suspicious cases occurred on the s.s. *Caledonia*; indeed, one of them, detained in hospital in Bombay, proved to be plague; the steamer *Golconda* from Calcutta and Madras arrived at Plymouth on 24th December with a case of bubonic plague on board, but the patient recovered in hospital; and the s.s. *Peninsular* from Bombay arrived on 14th October, 1899, at the same port with another case on board, the patient also recovering in hospital. Since January, 1899, it has appeared in both hemispheres, but to a much more limited extent than in the previous years—in Alexandria, 93 cases and 45 deaths in May; in Oporto, 282 cases and 104 deaths in August; in Santos and other Brazilian ports in October, infection being carried from thence to Cardiff, Capetown, and the United States; and, in addition, in Hamburg, Lisbon, Trieste, Sydney, St Petersburg, and San Francisco. The small outbreak in Vienna in October, 1898, arose from laboratory infection, and occasioned three deaths—viz. of the laboratory attendant, and of Dr Müller and a nurse who attended him during his illness. The Glasgow outbreak began in August, 1900, and by the end of September there were 36 persons attacked. Again in August, 1901, there was a return of the disease in the district of previous outbreak. On this occasion the persons attacked numbered five in all. In October of the same year, however, the disease again appeared in a different part of the city among the servants of a large hotel, of whom five were attacked. There has been no return of the disease in the city since that time. The total number of persons attacked was 46, and the total deaths numbered 16. The initial source of the infection remains a mystery, but the cause of the spread was the holding of "wakes" over the bodies of persons who had died of the unrecognised disease.

The causal factor of the disease is the *B. pestis*, which was discovered independently and simultaneously by Yersin and Kitasato in 1894.

They both found it in the blood and buboes of affected persons. It is a very minute cocco-bacillus, which is non-motile, and gives the appearance of a small squat bacillus. It measures from 1 to 2 micro-millimetres in length and about 0·5 in width. Kitasato states that at 37° C. it is motile, and Gordon, that it possesses terminal spiral flagella. It is non-sporular, and is a facultative anaerobe. It stains readily with anilin stains, but the best results are obtained from the use of carbol-thionin-blue and eosin, as stain and counter-stain. To examine sections for the organism, they are first stained with carbol-thionin-blue for five minutes on the slide, washed with water to get rid of excess of stain, then in water slightly acidulated with acetic acid and lastly in ordinary water. It is then counter-stained with a $\frac{1}{4}$ per cent. watery solution of eosin for about half a minute, washed in absolute alcohol to get rid of water, cleared in xylol, and mounted in Canada balsam. The staining exhibits well-marked bi-polarism, and the bacillus seems to be enveloped in a capsule. The *B. pestis* is differentiable from those organisms which resemble it, and which moreover may be found along with it in cases of mixed infection, in that it is not capable of being stained by Gram's method, while the pneumococcus, staphylococcus, and streptococcus are freely stained therewith. It is found abundantly in the affected glands, almost as a pure culture in the earlier stages of the adenitis, but as involuted forms usually in the suppurative stage ; and in the lung-tissue, the spleen, liver, kidneys, and other organs of the body. It can be cultivated easily in the ordinary media, but it grows most rapidly on blood-serum, forming slightly elevated, moist, cream-coloured growths. In gelatine it shows as an opaque white growth with irregular edges.

Plague attacks the lower animals, and there is clear evidence to show that it is communicable from them to man. Clemow [1] has made an exhaustive study of this part of the subject, and has shown that epidemic outbreaks occur in monkeys, in rats, bandicoots, squirrels, mice, guinea-pigs, porcupines, and marmots, of the class *Rodentia*, and that dogs, cats, pigs, and sheep are also susceptible but in a more limited degree, while goats are more susceptible than they, and horses escape infection under natural conditions. With relation to man, however, rat-infection is the most important. It has been definitely established that an epidemic of the disease in rats is commonly found to precede or run concurrently with the outbreak in man, and that the entrance of diseased rats into dwellings, or the handling of rats which have died of the disease, is in these circumstances the communicating factor to man. There is also some evidence to support the belief that it may be communicated from animal to animal and from animal to man by the intermediation of fleas, lice, bugs, and ants. The experiments of Montenegro of Madrid indicate that fleas, passing from the body of a rat which has died of the disease to that of a healthy rat, cause the latter to be attacked by the disease. At the same time, outbreaks of plague have occurred without manifestations of the disease in rats. In the outbreak in Glasgow there was nothing to point to its origin from rats, since in 236 of these animals which were caught within the affected area not a single one then betrayed any evidence of disease, and of 124 from other parts of the city which were examined, the like was observed. Later, however, it was found to be present in those animals to the extent of about 2 per cent. of those caught. More particularly, it may be said concerning the first outbreak in August and September, 1901, that the most careful search for infected rats failed to reveal any. Of 236 of these animals caught within the infected area, not a single one showed any evidence of any disease, much less plague; and the same was true of other 124 rats caught in other parts of the city. In the second outbreak in August, 1901, one infected rat in that month was found in the locality, and in the following month, five more plague-infected rats were discovered, three of these being alive and two dead. In the third outbreak in October, 1901, among the servants in the hotel, the mummified bodies of plague-infected rats were found under the floor of a refreshment room where those attacked were mostly engaged in their daily work. In addition, there were found in the vicinity of the hotel during a period of about a month after the outbreak 21 rats, dead or alive, all of whom were plague-infected. From that time till the end of January, 1902, infected rats were being found in premises in the neighbourhood of the hotel, and in an underground railway which leads to one of the docks in the harbour. Later, in July of the same year, infected rats were again found in the neighbourhood of the hotel and at the dock, and although in not a few instances some of these were caught in restaurant premises in which large numbers of persons were being employed, no further cases of plague were known. Certain observers have found the *Bacillus pestis* in the bodies of fleas and ants which have been feeding on the bodies of diseased rats. In Tidswell's Report of the Sydney outbreak, organisms resembling *B. pestis* were found in fleas, which, when injected into the body of the pig, produced the bubonic form of disease; and Hankin discovered the bacillus in ants which had fed on the bodies of rats which had died of plague.

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[1] *B.M.J.*, vol. i., 1900, pp. 1141, 1146.

From the reports of many observers, and perhaps chiefly from the exhaustive reports of the Commission on Plague Investigations in India, there cannot be the least doubt but that plague is disseminated from person to person by the agency of fleas. Much investigation has been made regarding this, as also on the question of the transmissibility of the disease to man by the fleas of the rat. Researches have made the following points clear:—(1) That different animals, including man, are attacked by different parasites of the flea species, but that, commonly, a particular flea attaches itself by preference to a particular host; thus *Pulex irritans* selects man as its host, *Ceratophyllus fasciatus* selects rats in Europe, *Pulex cheopis*, rats in Bombay and in the Punjaub, India, *Pulex felis* the cat and dog, *Ctenopsylla musculi*, mice and rats in various parts of the world, and *Sarcopsylla gallinacea*, birds; (2) That the species of rat attacked by *P. cheopis* is *Mus rattus* or the black rat, and the species attacked by *C. fasciatus* is *Mus decumanus* or the brown rat; (3) That the *M. rattus* is the most common rat of India, and *M. decumanus* the most common rat of Europe and of the British Islands; (4) That *M. decumanus* invaded this country in the eighteenth century and drove out *M. rattus*, or the black rat, which for centuries before was the common house-rat of Great Britain.

It has been said as a reason against the view that the spread of plague is due to the fleas of rats, that rat fleas do not bite men. Such has been maintained by Galli-Valerio,[1] Verjbitski,[2] and others.

The Indian Plague Commission has shown, however, "that *P. cheopis* will make use of man as a host, and may be captured in large numbers on men in houses infested with rat fleas," and Verjbitski, that human fleas bite rats, and can live as parasites on rats. It is not so clear that the flea of the brown rat, *C. fasciatus*, will bite man, or that *C. musculi* of rats found in other parts of the world will do so. But if the former part of this last statement be found to be true, it will account for the absence of outbreaks in Great Britain, since the flea parasite of the brown rat—now the domestic rat of this country—is *C. fasciatus* and not *P. cheopis.* The differentiating characters of the former flea are the following: it has well-developed eyes and possesses a pro-thoracic comb of bristles; of *P. cheopis*: it is small and light coloured compared with *P. irritans*, the human flea; it possesses a larger number of head-bristles than *P. irritans*, which possesses only one bristle on the posterior portion of the head; has no pro-thoracic comb of bristles; and its claws are smaller than those of *P. irritans.*[3]

Plague in man manifests itself in three typical forms—viz. the *bubonic*, *pneumonic*, and *septicœmic*. The first is characterised by enlargement of glands in different parts of the body, chiefly in the inguinal, axillary, and cervical regions. Boccaccio, in the Induction to his *Decamerone*, describes graphically the bubonic character of the plague in Florence in 1348. In this type of disease, swelling of a group of glands occurs on one side or other of the body, or one group on one side and a second on the other side, and as a rule one of the group forms a distinct bubo. The swollen glands are extremely tender to pressure. The tissues above and around the bubo become brawny and œdematous, and as the swelling increases and suppuration advances the overlying skin becomes deeply congested and purplish in colour, until the bubo bursts usually from the eighth to the tenth day, whereupon a deep ulcerated surface is left with ragged, undermined edges. The temperature during the first two or three days rises, until it may reach 104° or 105° F., remaining at these points for two or more days longer, then it falls towards normal, only again to rise before the bubo bursts, when it again falls. Should however septicæmic infection supervene thereafter, it again rises, and remains high until death supervenes. The *pneumonic* form is always found more or less prevalent alongside of the bubonic type. It may be suspected to be present when during bubonic plague the number of deaths from pneumonia increases. The mode of onset, symptoms, and progress are generally those characteristic of pneumonia. Lobular pneumonia is the rule, not lobar, but its signs are not so fixed as in lobar pneumonia; in other words, a dull area to-day may in a day or two clear up, and a second new dull area may be found. The sputum, which after twenty-four hours is more or less blood-stained, contains enormous numbers of bacilli. This form is more fatal than the bubonic. The septicæmic form is less common than the others. Whether it is due to a mixed infection or not has not yet been determined. It would appear, however, that the glands of the body are more or less generally affected, but not to a sufficient degree to cause definite swellings. Death commonly supervenes early, due to the profound toxic effect upon the system. In the Glasgow outbreak the type was mainly bubonic, but individual cases of both pneumonic and septicæmic types were observed.

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[1] *Centralb. f. Bakteriol.*, Abt. i., vol. xxvii., p. 1; *Jour. Trop. Med.*, vol. v., p. 33.

[2] *Thesis Univ. St Petersb.*, 1904, quoted by Plague Commission; *Jour. of Hygiene*, vol. viii., No. 2, p. 207.

[3] *Jour. of Hygiene*, vol. vii., No. 3, 1907, p. 455, Plate XII.

Symptoms.—The symptoms of onset observed in the Glasgow cases were severe headache, rigors, severe prostration, pain in back and limbs, and the bowels more often constipated than loose. The face of the patients was pale, especially about the mouth, the expression was dull and heavy, and presented an anxious look. This last appearance became more marked when the patient was moved, doubtless owing to the pain induced in the glandular swellings, even when the patient appeared unconscious to his surroundings. The temperature rose quickly, and by the second day reached from 102° F. to 105° F. It was remittent in character, being usually one or two degrees lower in the morning. The pyrexia ended either by crisis or lysis. Crisis occurred in the untreated cases at periods varying between 5 and 18 days after illness began. Where secondary septicæmic infection occurred the temperature continued high, as it did also in severe cases followed by early death. The amount of bubonic disturbance varied. In most of the cases the axillary and inguinal glands were simultaneously affected; in others, the enlargement was confined to one group of glands. In the milder cases resolution occurred with suppuration, but in the bulk of cases, a bubo went on to suppuration and ruptured, from which flowed a seropurulent, flaky discharge, which in all the cases but one proved to be sterile, or free from *B. pestis*. In the exceptional case, virulent plague-bacilli were obtained from the fluid discharged. Great tenderness on pressure of buboes was present. The skin of the patients was dry and hot; sweating was generally absent. No specific rash was observed, but mottling of the skin over trunk and thighs, more marked than the mottling of typhus but less than the mulberry eruption, was noticed. On its disappearance it left a dusky hue behind it. No petechiæ were found in the skin. The tongue was covered with a white fur and showed clean edges, but occasionally it exhibited a dorsal brown fur; the lips were dry, and sometimes covered with sordes. The respiration-ratio was notably increased, quite apart from any pulmonary complication. Pneumonia, however, was present as a complication in a number of the cases, in the form of patches, and not in lobar areas. Delirium and coma were more or less present in all the cases, but the former was usually slight and mildly delusional in type.

Some of the Glasgow cases were so slight that they might be named as of the type *Pestis ambulans*. The buboes were small, so much so at times that needle-puncture for diagnostic purposes was difficult. The temperature was rarely above 100° F., and was usually under that figure; but notwithstanding the apparent lightness of the infection, proved by finding the bacillus in the glands, the patients presented a heavy, drowsy-looking expression of face, increase of pulse—respiration ratio, injected conjunctivæ, and a furred tongue. In the typical pneumonic case large numbers of *B. pestis* were found in the sputum. This patient recovered. The Report on the Glasgow outbreak by Dr Chalmers, Medical Officer of Health, from which the foregoing details have been mainly obtained, contains a valuable original contribution by Cairns on the agglutinative property of blood-serum in plague cases, which is well worthy of study.

Incubation Period.—The average period is from three to five days, but it has been asserted that it may be shorter or that it may be longer.

Modes of Infection.—The bubonic form is believed to be due to the entrance of the *B. pestis* into broken cutaneous surfaces, such as from the bites of insects, or otherwise produced; and the pneumonic form, to be due to the inhalation of dust containing the organism. Kitasato has found *B. pestis* in the dust, and Yersin, in the soil of houses occupied by plague-stricken cases.

Modes of Spread.—There can be little doubt that as a means of spreading the disease from one place to another the presence of the disease in rats is a most important factor. In this way plague may be transmitted in ships from port to port. Whether the fleas of rats are capable of conveying the disease to man is not yet clearly decided, but that they are able to transmit it from animal to animal has been demonstrated. The disease may also be disseminated by air, water, food, or by direct inoculation. How far the spread, progress, and arrest of epidemics are influenced by climatic conditions is not yet well understood. From certain observations, Baldwin Latham has ventured the opinion that there is a marked relationship between the rise and fall of atmospheric vapour tension and the progress and arrest of plague.[1]

Preventive Measures.—Since evidence points so strongly to the existence of the disease in rats either previous to or contemporaneous with an outbreak in man, a vigorous crusade must be undertaken for the extermination of these rodents during the existence of an outbreak, or earlier if disease be observed in them. In the outbreak in China, it was found by Kitasato that in Kobé one rat in five, and in Osaka, one rat in ten was affected by plague. None of the rats killed in Glasgow in the infected area were found affected. Their extermination may be accomplished by trapping and killing, and by cremating their bodies. Danysz of the Pasteur Institute, Paris, has proposed to attain this end by feeding them with cultures of a cocco-bacillus resembling in general characters the *B. coli.* The plan seems to have been successful in Paris, Lille, Hamburg and other places, but it seems to have signally failed in Glasgow. Rats were fed with the serum, but none of them died, and of two which were inoculated with it only one died.

The Scottish Local Government Board of date 21st January 1902, issued to Local Authorities a memorandum with respect to plague. This circular contained general directions for dealing with rats in connection with that disease, and transmitted an order and relative regulations under Section 79 of the Public Health (Scotland) Act, 1897. The purpose of these regulations was to empower Local Authorities to deal effectively with diseased or infected rats and with rat-infested areas, the signal for the initiation of a campaign against rats being any unusual mortality among these rodents. Apart from ports, each Local Authority was to devise such measures as to them seemed likely to be most effective to extirpate these animals from a neighbourhood or area. For seaboard Local Authorities, the Board adopted the regulations laid down by the English Board and quoted those in their order, their intention being, if possible, to prevent the introduction of the disease into the country by ship-rats in port. These were as follow :—

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[1] *B.M.J.*, vol. ii., 1899, p. 1751.

1. When a ship arrived in port whereon during the voyage plague or suspected plague had occurred, the Local Authority was to take such measures as would secure destruction of the rats on board the ship. Rats were to be prevented from coming ashore by causing the ship to be moored at suitable distances from other ships, and from the shore, and by placing guards on hawsers and mooring-cables.
2. When a ship has come from any place infected with plague, notwithstanding no case of plague or suspected plague has occurred on board during the voyage, strict inquiry should be made on the ship's arrival as to mortality or sickness among rats during the voyage. If so, a sick rat should be secured, so that the nature of the disease from which it suffers may be duly ascertained. Should it be proved that the animal is suffering from plague, the ship should be dealt with as in the former paragraph.
3. Exceptional sickness or mortality among rats on board any ship, whatever may have been the port of her departure, should be viewed with suspicion, as prompting for such action as is laid down in paragraph 2.
4. Rats when destroyed on shipboard should not be handled but should at once be cremated.
5. When rats infected with plague are found on any ship, all parts of the ship frequented by these animals should, as far as possible, be disinfected.
6. The Authorities of seaport towns invaded by plague should institute forthwith a general campaign for the destruction of rats in the town, and primarily of rats in docks and quayside warehouses and stores. Measures should be taken to prevent shore rats getting on board vessels lying in port, and to destroy all rats on board ships about to proceed on their voyage. Captains of vessels should be urged to destroy during the ensuing voyage such rats on board ship as may have been overlooked.

The General Order contained in this circular, enforced in Article I., that the Local Authority shall take measures to ascertain regarding any prevalent disease or unusual mortality among rats within their district, and if such be found to exist, they shall at once report the facts to the Board, and take steps to ascertain whether any of such animals is suffering from plague ; and in Article II., that if plague is found or suspected to exist among rats within the district, or any neighbouring district, or in any ship lying in any water within the jurisdiction of a Local Authority, such Authority shall at once take the necessary steps to include plague among the diseases to which the Infectious Disease

(Notification) Act, 1889, applies, and shall adopt all necessary precautions to prevent the dissemination of the disease, and for that purpose shall take measures (*a*) to disinfect all places and to disinfect or destroy all articles that may have been exposed to infection; (*b*) to destroy all rats in the locality; (*c*) to prevent their entrance into houses, ships, and other premises; (*d*) to remove all deposits or accumulations of rubbish, refuse, manure, or other materials likely to attract such animals; and (*e*) generally to do everything calculated to stamp out the disease.

In addition to the ordinary well-known methods of destroying rats, newer methods have been devised by the use of cultures of bacteria which are inimical to rats but harmless to man. One of the best known, probably, is that sold as Danysz virus. Conflicting reports have been made as to its efficacy, but not a few have been entirely favourable. Its effect upon rats is to generate a disease which is communicable from animal to animal. Another of these is the organism of Neumann of Aalberg, which is said to be dangerous only to sucking pigs and sucking calves, but harmless to animals other than the rat, and also harmless to man. For destruction of rats in ships nothing more effective has been devised than the Clayton method by sulphur dioxide. When the gas reaches the haunts of the rats they have either to come out and be killed, or remain and be suffocated. The disadvantage of this gas is that it is not suitable for all kinds of cargoes, but, so far as rat-destruction is concerned, it is most effective.

Measures must also be taken to prevent its spread among human beings who have been exposed to infection. This may be attained by injecting a protective serum into the body. There are three such serums or vaccines—viz. Haffkine's, Yersin's, and that of Roux. They all confer immunity, but the degree of protection varies. Haffkine's vaccine is made by heating cultures of *B. pestis* to 70° C. for one hour, the serums of Yersin and of Roux are obtained from the serum of the blood of a horse which has been rendered immune by injection of dead plague-bacilli. For protective purposes, Yersin's serum may be injected in amounts from 10 c.c. to 40 c.c., but for curative purposes in those suffering from the disease the best effects are obtained from intravenous injections of doses from 40 c.c. to 100 c.c. The Plague Commission on anti-plague inoculation has declared that the ratio of mortality of uninoculated to inoculated persons during the outbreak of the disease in certain parts of India appeared to be nine to one. At the same time, because of the variations in statistical results, they were unwilling to condescend upon an arithmetical expression of the protective value of inoculation, although quite satisfied that inoculation had a sensible effect on the diminution and prevention of the disease.

In addition to such measures, all infected material should be burned, houses thoroughly disinfected, and bodies of persons who have died of the disease cremated, or otherwise satisfactorily disposed of.

Leprosy is a disease which has been known since the Mosaic dispensation, and probably since earlier times even, not only with respect to its clinical features but also to its communicability. The bacillus was discovered by Armauer Hansen in 1873. The disease prevails to-day in both hemispheres in limited areas. In Europe, it is found in Norway, Sweden, Spain, Portugal, Italy, Greece, Russia (Southern), Turkey, and some of the islands of the Mediterranean. In Africa, in the Cape, Senegal, and other parts. In Asia, in India, notably in Colombo, Ceylon, and in China; in certain islands of the Pacific as Hawaii and the Sandwich Islands; and in America, in Mexico, the West Indies, in New Brunswick, Louisiana and other places. Although endemic in Great Britain up till the end of the seventeenth century, it has now disappeared except in cases imported from abroad. An Act was passed in the Parliament of Perth, 1427, cap. 105, "Anent Lipper Folk." The disease chiefly invades the skin. It is due to a specific bacillus, but attempts to cultivate it out of the human body have up till the present signally failed. It appears to require for its growth living human tissue. The *Bacillus lepræ* measures from 5 to 6 micro-millimetres in length. It is stained with the ordinary stains, the methods of Ziehl-Neelsen and of Gram bringing out its characteristic features. The bacilli are found in abundance in the affected skin-areas. The disease exhibits itself in one of two main forms, although both may be found in the same subject—viz. the tubercular or nodulated form, and the anæsthetic form. The latter prevails largely in Africa and other tropical countries, the former being more common in Norway and other European centres. This disease seems to be uninfluenced by climate, since it is found in regions so diverse as Iceland, Central Africa and Honolulu, and while it is found largely on the seaboard, it obtains also in high inland places. Hutchinson believes it to be caused by eating partially cooked salt fish, but this view is not generally accepted; in fact, the intimate source of its origin is not known. It is contagious, however, not only among persons of the same nation, but to those of other nations. The case of Father Damien is a case in point. He died in Molokai, South Sea Islands, in 1889.[1] Its incubation-period is probably the longest of all the infective diseases. In Arning's case, in which he successfully inoculated the disease into the body of a convict, it proved to be about two years. This convict who was inoculated had no inherited taint. The disease was introduced into his body by suturing a piece of affected skin from a leprous girl nine years of age, who was the victim of tubercular leprosy, as well as by making punctures in different parts of the man's body. Four weeks after inoculation the man was attacked with an illness alike to apyrexial sub-acute rheumatism, the left elbow being the first joint involved, the left arm having been the site of the transplantation of the leprous skin. Then other joints became affected, the whole attack lasting four months. Thereafter, characteristic swelling occurred in the left ulnar and median nerves, which, however, subsided in six months. Meanwhile a typical leprosy nodule appeared at the site of the transplantation from which abundant leprosy bacilli were obtained.[2] *Nastin*, described by Deycke (*B.M.J.*, vol. i., 1908, p. 802), has been employed in the curative treatment of leprosy in a few cases. Raschid reports improvement in the direction of healing of ulcerations, subsidence of tubercles, softening of nodules, and restoration of sensation in certain cases after its use.[3] Nastin is the name given to a glycerin-aster of a high molecular fatty acid. Isolation of those affected seems to be the only measure of any value in arresting the spread of the disease, and this policy, as carried out in Norway and elsewhere, would appear to have been attended with some measure of success. Treatment seems to have but little effect upon the progress of the disease. Carrasquilla's serum-treatment is followed by improvement, the leprous ulcerations suppurate freely and heal rapidly, and ulcers previously anæsthetic become sensitive, but other observers have not found the improvement to be permanent.

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[1] *Lancet*, vol. i., 1889, p. 1000.

[2] *Wiener med. Woch.*, No. 29, 1889.

[3] *B.M.J.*, vol. ii., 1909, p. 1343.

Rabies or **hydrophobia**, which is produced in man by direct inoculation from the bite of a rabid animal, is believed to be of microbic origin, although the specific organism has not yet been isolated. Its incubation-period is variable ; the disease has developed as soon as six weeks after the bite, but it has also been delayed much longer than that. According to certain observers, it prevails more in summer and autumn than in winter. Of the deaths which have been recorded, more have happened in the male than in the female sex, and between the ages of five and fifteen rather than over the latter age. The specific organism apparently has its seat in the nervous centres, and chiefly in the spinal cord, or the toxines to which it gives rise act most on these centres. Pasteur based his line of treatment on that fact. He found that when a rabbit was inoculated by putting under the dura mater a piece of the spinal cord of an animal or person who had died of rabies, the inoculated animal developed the disease. If the spinal cord of the rabbit were then taken and exposed in perfectly dry air, he found that it lost its virulency in direct ratio to the period of exposure. By using, therefore,

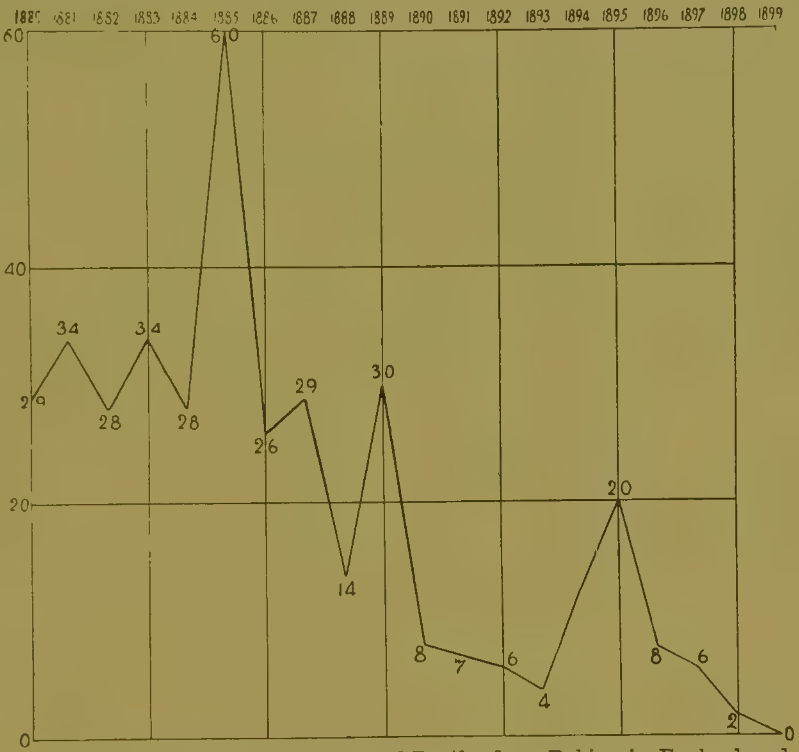

FIG. 113.—To illustrate Prevalence of Deaths from Rabies in England and Wales from 1880 to 1899 inclusive. The chart indicates the number of deaths for each year during that period.

cords of different rabic strengths, he was able to immunise dogs or human beings against the disease. In like manner, persons are treated who have been bitten by rabid animals. This treatment has proved very successful. The best preventive measure against the spread of the disease is the muzzling of dogs during the hottest months of summer, the destruction of all unowned dogs, and of those which exhibit suspicious symptoms. In 1892 the Board of Agriculture issued the Rabies Order, by which county authorities might set the above measures in operation. In 1897 (No. 5578), however, the order was enforced. The preceding figure shows the number of deaths in England and Wales from rabies from 1880 to 1899 inclusive, and the effect of the compulsory muzzling of dogs since 1897.

The repression of rabies has also been assisted, doubtless, by the Orders of the Board of Agriculture—viz. (1) Importation of Dogs Order, 1901, No. 6396, and (2) Importation of Canine Animals Order, 1909. By the former Order, it is laid down that no imported dog shall be landed in Great Britain, except from Ireland, the Channel Islands, and the Isle of Man, unless authorised by a licence of the Board previously obtained, and then only if for six months after landing it is detained and isolated at the expense of the owner upon premises under the control of a veterinary surgeon approved by the Board, and shall not be removed therefrom during such period of detention ; provided that the foregoing shall not apply in the case of a *bona fide* imported performing dog or of a dog which is intended to be exported from Great Britain within forty-eight hours after landing. The Order of 1909 applies to wolves, jackals, foxes, wild dogs, and other animals of the canine tribe under like conditions.

Cerebro-Spinal Meningitis, or **Cerebro-Spinal Fever.**—The past history of this disease in civilised countries in earlier times does not appear to be so definite as that of other infective diseases. Research has indicated, however, that it has prevailed in both hemispheres prior to the nineteenth century, if we may judge from the train of symptoms recorded of certain ill-defined epidemics. According to Hirsch,[1] there appeared in certain districts of France and Southern Italy, toward the end of the thirties of the last century, a form of epidemic disease which was not recognised, but the phenomena of which were mainly indicative of inflammation of the meninges of brain and spinal cord. The disease later received the name of *Meningitis cerebro-spinalis epidemica*, or *Typhus cerebralis*. Within the following twenty-five years, it had spread over a large part of Europe, and had appeared in Western Asia, in Africa, and in South America, becoming epidemic at times in the United States. From that time till the present, it would seem as if there had been in Europe and the United States five separate epidemic waves of the disease—viz. (1) in 1805–1830 ; (2) in 1837–1850 ; (3) in 1854–1875 ; (4) in 1876–1884 ; and (5) in 1900–1909. It has, perhaps, been more consistently present in the United States of America than in any other part of the world, and hence some have designated it the "American disease." If we confine our attention to its outbreaks since the middle of last century, we shall find that it was probably never absent from some part of the United States in epidemic form between the years 1857 and 1874. In the winter and spring of 1845–1846, it broke out in the workhouses of Dublin, Bray, and Belfast, and at the same time some cases were recorded in Liverpool. There was another outbreak in Dublin in 1850, and still another in the same city in 1866–1867, chiefly, on this occasion, among the soldiers in barracks. In this latter year, there were a few cases in a village near Lincoln. In 1876 there was a small outbreak at Birmingham. In 1884 there was a series of cases in Galston, Ayrshire, recorded by Dr Frew. Again in Dublin in 1885–1886 many cases were recorded.[1] Sweden was severely attacked on two occasions, and on each the epidemic continued for some time. The first occasion was in 1854–1860, and the second in 1865–1867. The number of deaths recorded from both epidemics was 4577. Germany has experienced several epidemics, one of the most severe being probably that of 1863–1866, during which years, also, it was present in epidemic form in Austria and Hungary, an orphanage in Vienna being attacked in 1863.

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[1] *Handbook of Geographical and Historical Pathology*, vol. iii., p. 547. (New Syd. Soc. Ed.)

Coming to nearer times, an outbreak was recorded at Roccella, a village near Palermo, Italy, in the beginning of 1888 ; fairly numerous cases occurred in Berlin in 1889, and in the province of Ontario, Canada, since 1897 there have been 1140 deaths from the disease. In 1898, 38 cases were intimated in Chicago, of which 25 proved fatal, the organism having been found in six in which a post-mortem examination was made. In 1899, there were 68 deaths in Great Britain, of which 19 were in England, 4 in Scotland, and 45 in Ireland. Of the fatal English cases, 9 occurred in Haslar Hospital among boys from the ship *Saint Vincent*, at a time when influenza of a grave type was prevalent.

Dr Flinn reported to the Irish Local Government Board in 1905 respecting an outbreak in Dublin in 1901. The cases numbered 80, of which 38 were between one and five years of age, 38 between five and twenty, 12 between twenty and forty, and 4 between forty and sixty years. Nine cases were under one year.

In December 1901, there was a small outbreak in H.M.S. *Northampton*—a training-ship for boys—consisting of 12 cases with several deaths, and at the same time the disease appeared in H.M.S. *Calliope*, another training-ship. It was thought not impossible that the infection was conveyed to the latter from the former.

In a Report by Carlo França, chief of the staff of the Bacteriological Institute, Lisbon, it is stated that during the epidemic in that city in 1901 and 1902, 310 patients were treated in hospital, 48 being under five years, 65 between five and ten, 68 between ten and fifteen, 49 between fifteen and twenty, 40 between twenty and twenty-five, and 39 between twenty-five and fifty-five. Ninety per cent. of the patients showed Kernig's sign. The death-rate was 52 per cent.

M'Gahey records a serious and widespread epidemic which broke out in Yola, Northern Nigeria, a town of 22,000 inhabitants, which is situated on the Benne River about 1000 miles from the coast. It began in February, 1905, and lasted till the end of April, during which time it spread over the greater part of Northern Nigeria, travelling in a westerly direction and confining itself very largely to trade-routes. The months in which it occurred are the hottest in the year, the temperature on several occasions attaining 108° F. in the shade. The natives had had no experience before of the disease, but in other parts of the Nigerian Protectorate spotted fever had been known previously. Three to five per cent. of the entire population of the infected towns were attacked, and the death-rate was about 50 per cent., rapidity of seizure being a marked feature of attack during the prevalence of the epidemic.

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[1] *B.M.J.*, vol. i., 1886, p. 126.

In January, 1902, a small outbreak appeared in the burgh of Paisley. We were brought into touch with it in the following manner. Four persons, mainly children, had died somewhat suddenly and unexpectedly. The popular rumour was that their deaths were due to some poisonous substance in fried fish and potatoes of which some of them, at least, had partaken in a shop. Owing to the prevalent excitement, the Corporation of Paisley asked us to make a post-mortem examination of the body of one of the supposed victims, a young girl, and to report. The post-mortem examination revealed a plentiful seropurulent exudate all over the major portion of the pia mater and along the major portion of the spinal cord. Samples of the exudate were taken in sterile tubes, and after examination we were able to isolate a diplococcus of an intracellular character corresponding to Weichselbaum's meningococcus, and to produce photomicrographs of the organism as part of our report. The total number of deaths recorded before the disease disappeared was nine. In Greater New York, during the winter of 1904 and the spring of 1905, there were 4000 cases reported, of whom 3429 died, the deaths in 1904 being 1403, and in 1905, 2026.[1]

In the early months of 1905, the disease broke out in Vienna.[2] In several of the affected districts it was noted that a disproportionately large number of domestic animals were suffering from brain diseases, and on examination, the Silesian Health Department succeeded in isolating the meningococcus from the nasal discharges of both horses and goats. From the commencement of the outbreak in April, nearly 1000 persons had died in Austria of the disease. In Vienna in June of that year, there were notified 45 fresh cases with 32 deaths, and in July, 22 fresh cases with 14 deaths. In the same year some cases appeared in Irthlingborough, Northamptonshire, which were reported by Dr Reginald Färr of the English Local Government Board.

In the years 1906–1908 outbreaks took place in Glasgow, Edinburgh, Leith, and other places in Scotland, and in Belfast in Ireland. From February till September 1907, 1611 cases in all were reported to the Scottish Local Government Board from 24 different counties. But seven of these counties contained 83 per cent. of all the cases, the majority of that percentage being in Lanarkshire, and the bulk of the cases in Glasgow and immediately neighbouring burghs.

Owing to the re-appearance of the disease in England and in Scotland, the Local Government Boards of these respective countries in August and September 1905 issued circulars thereon to Local Authorities. Although in 1905 only a few odd cases were noted as occurring in Glasgow, additional cases were observed in different parts of the city in the early months of 1906, and the Medical Officer of Health, Dr A. K. Chalmers, issued a memorandum on the subject on 31st May of that year. Carefully scrutinising the death-returns referable to brain and meningeal diseases, he found that during the first six months of 1906 the number of deaths returned from tubercular meningitis remained about the normal level, but that the number returned from meningitis had considerably increased. In the latter half of that year, however, both sets of returns showed increased numbers of deaths, and, in addition, deaths were being certified from cerebro-spinal meningitis. There could be little doubt that deaths were being attributed to ordinary meningitis which ought to have been debited to the former disease.

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[1] Flexner, *B.M.J.*, vol. ii., 1906, p. 1023.

[2] *Ibid.*, vol. ii., 1905, p. 259.

The cases registered during 1906 of cerebro-spinal meningitis numbered 213, of which, however, 21 were found not to be of that disease. Of the 192 cases which remained, 87 were verified, and 105 not verified by bacteriological examination. Of the 87 verified cases 65 died, and of the 105 non-verified cases 76 died. The total number of cases of the disease in 1906 was 205, being a case-rate per million of 255, with 143 deaths or a death-rate per million of 178. The disease was made notifiable on 10th August, 1906, and was renewed for another year in 1907. In 1908, it was added permanently to the list of notifiable diseases.

During the following year, 1907, 998 cases were notified, 802 of these being between 1st January and 30th June, and the remainder, 196, between 1st July and 31st December. The number of deaths was 683. Of the total cases, 72 per cent. were under ten years of age.

The following Tables[1] are instructive:—

TABLE XXXVII

Age-Groups	Jan. 1—June 30, 1907			July 1—Dec. 31, 1907			Totals			Percentage of Cases at Different Ages
	Males	Females	Total	Males	Females	Total	Males	Females	Total	
Under 12 months	51	52	103	26	18	44	77	70	147	14·7
1–5 years	170	168	338	40	34	74	210	202	412	41·3
6–10 ,,	62	66	128	13	18	31	75	84	159	15·9
11–15 ,,	39	44	83	7	6	13	46	50	96	9·6
16–20 ,,	33	15	48	5	4	9	38	19	57	5·7
21–30 ,,	29	19	48	5	3	8	34	22	56	5·6
31–40 ,,	18	12	30	6	1	7	24	13	37	3·7
41–50 ,,	10	7	17	5	3	8	15	10	25	2·5
Over 50 ,,	5	2	7	—	2	2	5	4	9	0·9
Totals	417	385	802	107	89	196	524	474	998	
Percentages	51·9	48·1	100	54·6	45·4	100	52·5	47·5	100	

From an analysis of 595 of these deaths, it was found that 118 took place on the first day of the illness, and that a decreasing number occurred on each following day during the first week.

The epidemic continued into the year 1908, but was on the decline. The total number of cases recorded was 240, giving a case-rate of 300 per million of population, as against 998 cases recorded in 1907 with a case-rate of 1237 per million. The total number of deaths was 155, which was a death-rate of 193 per million, as contrasted with the death-rate of 1907, which was 847 per million.

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[1] *M. O. H. Report*, 1907.

Table XXXVIII

Showing Number of Deaths and Percentage of Deaths to Cases Intimated at different Ages during 1907 *in Glasgow*

Age-Groups	Males		Females		Total	
	Number of Deaths	Percentage of Deaths to Intimations	Number of Deaths	Percentage of Deaths to Intimations	Number of Deaths	Percentage of Deaths to Intimations
Under 12 months	62	80·5	51	72·8	113	76·9
1–5 years	150	71·4	148	73·3	298	72·3
6–10 ,,	49	65·3	54	64·3	103	64·8
11–15 ,,	24	52·2	34	68·0	58	60·4
16–20 ,,	21	55·3	11	59·3	32	56·2
21–30 ,,	19	55·9	18	81·8	37	66·1
31–40 ,,	14	58·3	8	61·5	22	59·5
41–50 ,,	10	66·6	6	60·0	16	64·0
Over 50 ,,	2	40·0	4	100·0	6	66·6
Totals	351	67·0	334	70·5	685	68·6

In the Burgh of Partick, adjacent to Glasgow, cerebro-spinal meningitis was first reported in July, 1906, and in that year 12 cases occurred, of whom 8 died, 3 cases occurring in members of one family. During 1908, 69 cases were reported, of which 41 were reported in the first quarter of the year, 19 in the second quarter, 6 in the third quarter, and 3 in the fourth quarter. In this burgh the disease also appeared in the more densely populated localities, and persisted in maintaining its infectivity in these areas. Of these 69 cases, 46 died, thus giving a mortality-rate of 66·6 per cent. Of 76 cases notified as suffering from cerebro-spinal fever, 59 were verified bacteriologically, 10 were negative or were not examined, and 7 were due to other organisms, 4 to tubercular meningitis, 2 to pneumococcal infection, and 1 due to infection by *B. typhosus.*

In connection with 54 cases occurring in 48 houses, 230 contacts were examined bacteriologically. In 53 of these contacts the meningococcus was found after cultural and microscopic examination.

In one case in Partick, the initiatory presence of the disease was indicated by pneumonia, in the sputum of the patient a Gram-negative diplococcus being found. Two days later, symptoms of cerebro-spinal fever developed, and the organism was found in the spinal fluid by lumbar puncture.

In Edinburgh, the deaths formed 78 per cent. of the cases, and in Leith 74·4 per cent.

In Belfast in 1907 the number of cases recorded was 623, of whom 493, or 79·2 per cent. died.

Even of hospital-treated cases the mortality was heavy; in Ruchill Hospital, Glasgow, of 202 cases treated, 79·2 per cent. died; in Edinburgh Fever Hospital of 108 cases, the mortality was 80·5 per cent.; and in Belfast Fever Hospital, of 275 cases it was 72·3 per cent. The number of cases in Dublin in 1907 was relatively much fewer than those in the other places named.

Natural History of Propagation.—Hirsch affirms that, in regard to manner of outbreak, incidence, and diffusion as an epidemic, this disease shows peculiarities from other microbic diseases. It appears, for example, in localities in which, so far as known, it had never before been seen, and it proceeds, not infrequently, *per saltum* rather than by continuous progression; in other words, it breaks out in places far apart from one another, and the inhabitants in the vicinity of the places invaded and those of the intervening districts remain free. Thus it does not seem to spread along lines of traffic. In some places it will appear in a definitely epidemic form, in others, only as sporadic cases; in some, the epidemic continues over months or years, in rarer instances it lasts only for a few weeks. Moreover, in places in which it does break out, cases seem to appear in recurrent crops, intervals of time elapsing between the recurrent groups of fresh cases. It is further noteworthy, that in some epidemic outbreaks its appearance was closely associated with grouping or aggregation of persons, such as children in orphanages, inmates of workhouses, and soldiers in barracks. This, however, has not been exhibited in the recent epidemics in Glasgow, Belfast, Edinburgh, Leith, and other places. Hirsch points out that of 62 epidemics in France, 43 were absolutely confined to soldiers in barracks, 6 mainly to soldiers but partly to civilians, and in 5 it was equally prevalent among soldiers and civilians.

The subjects of aggregation of persons relative to the spread of the disease and of its lateral spread were carefully studied during the Glasgow epidemic by the Medical Officer of Health. With reference, for example, to the association of children in schools, it was shown that in 38 schools single cases only occurred, in 17 schools two cases developed, in 6 schools three cases, and in 4 schools four cases each; thus 27 schools had multiple cases, but in no instance more than four cases. In only five instances was it found that two children in the same class were attacked. In one school, both the children sickened on the same day, in a second school the interval of sickening of the two cases was eleven days, in a third the interval was 42 days, but in this last instance, in the interval referred to, a third child in another class sickened. In a fourth school, the interval was five days, and in the fifth the interval was 47 days. With regard to lateral spread, in 24 instances only was there more than one house in a tenement invaded. The following Table is instructive in this regard:—

TABLE XXXIX

Showing Interval between Invasion of separate Houses in Same Tenements

	Days							Weeks			Months						Total
Intervals . .	1	2	3	4	5	6	7	2	3	4	2	3	4	5	6	7	
Number of Instances	1	–	2	–	1	1	–	3	–	4	5	2	2	–	1	1	23

In addition to these, there was one instance in which two houses in the same tenement were invaded within twenty-four hours of each other. It is, also, not unimportant to note that the disease recurred in some houses after they had been disinfected by the Sanitary Authority. Examples of infection directly from an existing case are, so far as known, rare. Two cases, curiously enough of medical practitioners so infected, have been recorded—viz. the fatal case of Dr Albert B. Craig, who contracted the disease from a patient on March 14th, 1905,[1] and that of one of the assistant medical officers of health of Glasgow, who recovered after a protracted illness. He was attacked six days after visiting a house in which the disease existed, and in which the smell was so foul as to nauseate him.

Cerebro-spinal meningitis is chiefly a disease of the young, although in certain epidemics it would appear as if the adult population were chiefly the subject of attack. The tables already given for Glasgow indicate the greater frequency of attack of the young. In 1907, for example, 72 per cent. of the total cases were of children under ten years of age. If the age be extended to fifteen years, a much larger percentage is included. During 1906 in Glasgow, 24 infants fed on breast-milk alone, 11 fed on artificial food, consisting of condensed milk and porridge, were among the victims of attack, all of them being under twelve months of age.

Conditions of Outbreak.—Like typhus-fever, this disease appears to have its habitat amid insanitary surroundings—to be associated very closely with uncleanliness of person and of home, and with crowded, ill-ventilated, and dirty dwellings. In the Glasgow epidemic, the disease was found most to prevail in the densely-populated districts inhabited by a working-class population. Probably the outstanding factor which determined the incidence of the disease in dwellings was atmospheric pollution. Of 23 invaded houses in one ward of the city, 11 were definitely dirty, although not filthy in the sense of demanding administrative action of the Sanitary Authority; in another ward, of 50 invaded houses, 12 were definitely filthy; and in a third, of about 60 invaded houses, in six only was there any great degree of dirtiness. On the other hand, in 40 invaded houses relative cleanliness obtained. Overcrowding, which leads to atmospheric pollution, would seem, therefore, to be a more potent factor than relative dirtiness in a dwelling. In one two-apartment house of a little over 2100 cubic feet capacity, occupied by 10 inmates, five adults and five children, five were attacked fatally by the disease. Probably in the last analysis, therefore, atmospheric pollution will be found to be the chief factor which contributes to the spread of the disease.

Climatic Factors.—Various observers have reached the conclusion that cerebro-spinal meningitis is a disease which is mainly associated with relatively low temperatures. No doubt this has been found concomitant with outbreaks in very many instances, as has its disappearance been noted on the advent of higher temperatures. This is in some measure borne out by the numbers of attacks during the year 1907 in Glasgow. The number attacked between 1st January and 30th June was 802, whereas between 1st July and 31st December it was only 196.

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[1] *B.M.J.*, vol. i., 1905, p. 750.

Such a doctrine must, however, be cautiously adopted, because in certain recorded widespread outbreaks the temperature has not been relatively low but relatively high. Its incidence in the colder months of the year may be due, as in typhus, to the fact that it is during these months the poor herd more closely together for purposes of warmth, thus generating atmospheric pollution of the apartments in which they live.

Hirsch, from a survey of the epidemics in various countries over nearly a century, has reached the opinion that the disease is usually one of winter and spring and rarely of summer and autumn, is chiefly confined to temperate and sub-tropical latitudes, has not penetrated far into the cold zone, and has not at all invaded the tropics.

Infectivity.—The disease may be said to be one of relatively low infective power, and of limited range of infectivity.

During the currency of the Glasgow epidemic, Dr R. M. Buchanan, the city bacteriologist, from investigation proved that the organism is likely to be found in the naso-pharyngeal secretions of the majority of those suffering from cerebro-spinal fever, and also, like the organism of diphtheria, may occasionally be found in these secretions in otherwise normal healthy persons. It has already been observed that organisms having some resemblance to the meningococcus are also found in these secretions, notably the *Micrococcus catarrhalis*, and therefore it was only after bacteriological differentiation that Buchanan was able to arrive at that conclusion. He made further special investigation into the prevalence of the meningococcus in the secretions of persons who had been in contact with victims of the disease, by taking swabs from the vault of the naso-pharynx by way of the mouth. In all he examined swabs thus taken from 370 contacts, of which, however, 62 had to be rejected for different reasons. The remaining 308 cases represented members of 74 families, and of these in 81 instances, or at the rate of 26·3 per cent., was the meningococcus found. In 51 families it was found in one or more members. In 31 it was recovered in one member, in 14 in two members, and in one family in five members. But in not a single case did the disease develop. He also found that the organism, from the time it was first discovered in the naso-pharynx of these healthy contacts, persisted in that habitat from seven to seventeen days thereafter. Of 24 patients in hospital—sufferers from the disease—the organism was found in the same region up to ninety-four days after first detection, while in some who recovered it was found, in one case two years after recovery, in two cases after twelve months, and in one case after three months. The age-incidence of the contacts in whom the meningococcus was found showed that those above school-age bulked most largely in number; thus, from under one year of age up to fifteen years the number was 30, while from fifteen up to sixty-five years the number was 51. These results were only reached after microscopic and cultural differentiation of the organism. Poleduc made an investigation while the disease was in Pola, the naval station of Vienna, to ascertain if the meningococcus could be found in the noses of healthy persons. His results, which were as follow, he communicated to the Vienna Clinical Society. He examined 207 healthy contacts, of whom 25 gave positive results, the cocci being found as long as 18 days after first detection.[1]

Symptoms.—The onset of the disease is usually sudden. Children commonly complain first of being tired, older children, of headache and shivering. Not infrequently, vomiting is an early accompaniment. In acute cases, stiffness of the muscles of the neck with retraction of head is seen early, but in less acute cases these may be preceded by an interval of feverishness at night, and gradually increasing restlessness with vomiting more or less persistent in character, during which the features become pale and pinched, and the tongue dry and covered with a whitish or brownish fur. With the retraction of the head—the movement of which causes the patient pain—there is commonly dilatation of the pupils, and there is accompanying apathy, with more or less stupor and intermittent delirium. Strabismus is a common sign, particularly in the later development of unconsciousness. The temperature ranges between 100·5° F. and 103° F. in the average case. The decubitus is characteristic, the head is considerably retracted, the thighs are flexed on the abdomen, the spine is arched forwards. The breathing becomes superficial, and, later, Cheyne-Stokes in character. A scanty, irregularly-distributed rash, petechial in appearance, makes its appearance. The spots are about the average size of hemp-seed, are more pronounced than the typhus-rash, and usually are more located in area of distribution than the rash of typhus. From this skin-manifestation, the disease doubtless received the designation of "spotted fever." In cases going on to a fatal issue, the coma becomes deeper and deeper until the patient cannot be aroused to consciousness by any stimulus.

Post-mortem Appearances.—We have made several examinations of the bodies of those who have died of the disease, and the outstanding appearances found consisted of a purulent or sero-purulent exudation on the surface of the brain and spinal cord along the tracks of vessels in the pia mater.

Bacteriology.—Meningeal infections, producing the same general train of symptoms, may be due to organisms other than the meningococcus, as for example, to Friedländer's pneumococcus and to *B. typhosus*; hence, in order to arrive at a correct diagnosis, the causative organism must be differentiated. It will be, however, near the truth to say that meningeal infections by the two last-named organisms are relatively much less common. To these must, of course, be added *B. tuberculosis*. Usually, the diagnosis may be established by the discovery of the organism in the fluid obtained by lumbar puncture. Some observers have gone as far, however, as to declare that if this fluid contains an excess of polymorphonuclear leucocytes, the case is probably due to meningococcal infection rather than to any other form.

The bacteriological history of cerebro-spinal fever, put shortly, is as follows: Prior to 1886, various observers had recorded as present in the meningeal exudation of cases exhibiting the symptoms of meningitis organisms of the coccal type. Klebs, Eberth, Gaucher (1881),[1] Leyden,[2] and Ughette[3] in 1883, Marchiafava and Celli[4] in 1884, were among the earliest of these. In 1886, however, Leichtenstern[5] described an intercellular organism, not unlike the *M. gonorrheœ*, which he had found in the exudate of a patient during an epidemic outbreak of the disease. But, like all the preceding observers, he had failed to cultivate the organism in artificial media. In 1887, Weichselbaum,[6] after an investigation of eight cases, gave a full description of the organism which he had found in six of these cases, and which, being diplococci, differed from the organism found in the other two cases, which proved to be pneumococci. He characterised the diplococcus found in the six cases (1) as occurring in pairs, (2) as being within the protoplasm of the leucocytes, and (3) as being decolorised by Gram's stain. These observations were confirmed by other observers, as Goldschmidt[7] in 1887, and Netter[8] in 1889. Up till this time it was made clear that two different organisms, the diplococcus of Weichselbaum and the pneumococcus of Friedländer, were capable of giving rise to meningeal affections which exhibited markedly identical clinical symptoms. By reason of this, a controversy arose as to the exact character of the organism causative of cerebro-spinal meningitis, namely, as to whether the two organisms were the same, or the organism described by Weichselbaum was merely a phase of the pneumococcus or whether they were different organisms. Many were inclined to support, and some did support in writing, the view that the former was merely a variety of the pneumococcus, while, on the other hand, others as strongly urged the view that the former was a distinct and separate organism, and that it was the specific causal agent in epidemic cerebro-spinal meningitis. The evidence of later years has gone far to substantiate the correctness of the latter view, and few, perhaps, have supported it more strongly than Jaeger[9] and Councilman, Mallory and Wright in their report on this disease to the Massachusetts State Board of Health, and many others. The disease was reproduced clinically and pathologically in goats by Huebner, who injected sub-durally into these animals pure cultures of the meningococcus obtained from human cases of the disease, and a like result was produced by the reporters to the Massachusetts Board in a goat by injection of the diplococci of Weichselbaum into the spinal canal of the animal. Inoculation of the organism into the peritoneal cavity of mice invariably causes death within 48 hours, post-mortem examination revealing peritonitis with a glairy exudate, the leucocytes of which are full of the organism both intra-cellular and extra-cellular.

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[1] *B.M.J.*, vol. ii., 1905, p. 1231.

In 1901, Nuthall and Hunter[10] made bacteriological examinations of the fluid obtained by lumbar puncture from nine cases of meningitis in children, and from one case in an adult, They declared that the true nature of the disease, whether tubercular or other, could not be diagnosed from the clinical symptoms alone. In each of the cases examined, a diplococcus was found in the spinal fluid, was isolated, and was proved to have the following characters:—(1) Microscopic Appearances: Cocci in pairs, tetrads, or short chains variable in size especially in cultures, but the cocci in pairs were coffee-bean-like in form; (2) Stain characteristics: The organism stained well with methylene blue, fuchsin, and other ordinary stains, and gave indefinite and unreliable results with Gram-Weigert stain, and with the Claudius modification of the same. In the minority of cases decolorisation took place, but in the majority, the stain was retained. St Clair Symmers and Wilson[1] examined during the Belfast epidemic the lumbar spinal fluid in 31 living cases, and in 27 of these the meningococcus of Weichselbaum was obtained by culture, and of 37 further cases after death, with a like result in 22 of these, the remaining 15 cases giving cocci which were Gram-positive. In six additional cases in which post-mortem section was made, the organism was found in the spinal fluid or in the pus of five. Thus they had examined in all 75 cases with positive results in 52, in which the organism was cultivated artificially. The cultural characteristics of the organism thus isolated were these: Colonies were smooth circular discs, having a smooth regular contour, and a peculiar translucent grey colour; are only slightly raised above the surface of the medium; vary in size from pin-point to discs of 5 μ in diameter after 48 hours' growth; and are usually discrete. Microscopically, they are cocci indistinguishable in shape and size from gonococci, although some are smaller, but commonly they present the characteristic flattened apposed surfaces. Tinctorially, the organism was Gram-negative, on using Czaplewsky's modification of the Gram stain, viz.: two minutes in carbol-gentian violet, one minute in Lugol's solution, wash thoroughly in absolute alcohol, dry the film, apply aqueous fuchsin for about two seconds to half the area of the dry film, wash quickly in water, dry, and mount. Culturally, the organism does not grow at 20° C.–22° C. Media containing dextrose and maltose are fermented with production of acid, while those containing galactose and saccharose are unchanged. They found the most satisfactory solid medium for growing the organism to be one composed of one part of raw ascitic fluid and two parts of 3 per cent. agar, this being prepared by allowing the melted agar to cool to 55° C., then to add the ascitic fluid of the like temperature, pour into tubes as slants and incubate for 24 hours to sterilise. They found that the organism would live in this medium for 7–12 days. At the same time, they found that the organism lived longer in a fluid medium composed of bouillon with three parts of added raw ascitic fluid, to which glucose or maltose might be added. It also grows at 37° C. on gelatin to which ascitic fluid is added. Indol is produced in ascitic bouillon. Cultures from pus are best made by inoculating the solid medium in a Petri plate, and also from spinal fluid, the plates being then incubated for twenty-four hours, and sub-cultures taken from the colonies developed. It ought to be added that the meningococcus has also been found in the blood of patients. Their conclusions were (1) that the organism is Gram-negative, (2) does not peptonise gelatin, (3) produces indol, (4) forms acid in glucose and maltose media, but not in galactose, and (5) does not produce gas.

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[1] *Gaz. méd. de Paris*, 1881.

[2] *Zeit. f. klin. Med.*, 1883.

[3] *Giorn. d. Soc. d' Igiene*, 1883.

[4] *Gaz. d. Osped.*, 1884.

[5] *Deutsch., med. Woch.*, 1886.

[6] *Fortschritte der Medicin*, 1887.

[7] *Centralb. f. Bakt.*, 1887.

[8] *La France médicale*, 1887.

[9] *Zeit. f. Hygiene*, 1895.

[10] *B.M.J.*, vol. ii., 1901, p. 784.

One of the most valuable inquiries into the differentiation of the coccal organisms found in saliva, and the distinctive characters of the meningococcus, is that contained in a report to the English Local Government Board in 1907 by Dr M. H. Gordon. Gordon's method of identifying the meningococcus is as follows: a lemco broth medium with some added raw ascitic fluid, tinted with litmus, and containing one or other of various sugars is prepared, and observation is made regarding the production or non-production of acid. He states that the meningococcus produces acid-reaction with glucose, galactose, and maltose, but not with saccharose, while the *Micrococcus catarrhalis* exhibits no such reaction with all four; the gonococcus gives positive acid reaction with glucose and galactose, but negative with maltose and saccharose. He has also given special attention to the differentiation of the meningococcus from other Gram-negative cocci found in normal saliva. Of 127 examples of cocci found in saliva, no fewer than 114 were distinguishable from the meningococcus by their sugar-reactions; 80 gave a positive reaction with saccharose, 54 a negative reaction with galactose, and 9 a negative reaction with glucose. Of 13 of the Gram-negative cocci which gave like sugar-reactions to the meningococcus in respect of glucose, galactose, and maltose, 7 also gave a positive acid-reaction with mannose, in which the meningococcus proves negative. The chief distinctive feature, however, which differentiates these from the meningococcus is that they grow freely on "*nasgar*," that is, Wassermann's nutrose ascitic agar-medium, at 23° C.–25° C., while the meningococcus does not grow in that medium at that temperature, although control cultures grew well at 37° C. Gordon does not rank as very high the value of the agglutinative test; in fact, he does not recommend it as a means of differentiation.

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[1] *B.M.J.*, vol. i., 1907, p. 1477.

In differentiating the meningococcus from other coccal organisms found in the naso-pharynx, Buchanan used the following medium:—

Ox blood serum —three parts.
Bouillon —one part.
Glucose —one per cent.
Neutral red (as indicator)—0·5 in 10,000 parts.

After mixture, the medium is put into Petri plates, and is solidified by gradually raising the temperature of the medium. It is sterilised by being heated for two hours daily on three successive days. The surface of this medium is inoculated by the material from the swab. After 12 to 18 hours' incubation at 37° C., a mixed growth of organisms takes place. The meningococcus grows rapidly, and shows its presence in the form of pinkish-coloured, round, smooth, moist, shining, and slightly-elevated colonies. The pinkish colour is due to the production of acid. The colonies of the *M. catarrhalis* are not coloured because that organism does not produce acid. The organisms in the pink colonies, when examined microscopically, are found to consist of cocci in pairs, resembling the gonococcus. In each pair the point of apposition shows flattened or concave surfaces, thus causing the cocci to have a coffee-bean-like appearance. These are best observed after they have been stained with 1 : 10 carbol-fuchsin. The best confirmatory tests in sub-cultures are, according to Buchanan, the following: in glucose and maltose neutral-red blood serum and bouillon, the meningococcus produces acid-reaction, imparts fluorescent coloration to water of condensation, and gives a yellow deposit therein of the growth, not unlike pus in appearance, after 18 hours' incubation; while in galactose and saccharose media, although the organism grows freely, no apparent acid-change seems to take place.

Treatment.—Ordinary treatment does not seem to produce much effect on the progress of cases. In the outbreak in Vienna, the treatment most relied on was hot baths. Various drugs have been recommended, but their virtue is very doubtful. Lumbar puncture and withdrawal of small amounts of spinal fluid does, undoubtedly, for a time at least, relieve intra-spinal and intra-cranial tension, and seems to ameliorate the symptoms. This operation, repeated on several occasions, has been followed by significant relief. By reason, however, of the apparent valuelessness of ordinary treatment, attention was quickly drawn toward the possible value of antiserum-treatment. Not a few anti-sera have been prepared, and the curative potency of most of them has been tried with conflicting results. Some of these are known by the names of Kolle and Wassermann, Ruppel, Burroughs & Wellcome, Jochmann, Flexner and Jobling; and there are others. Currie and M'Gregor [1] reported on their experience of serum-treatment in one of the Glasgow Hospitals to the following effect:—(1) that, on the clinical side, no obvious or constant train of events followed the injection of serum; (2) that, on the statistical side, the case-mortality was not curtailed, and there was no increase in the number of patients who survived the first ten days; (3) when, however, serum-treated survivors of the first ten days were compared with untreated survivors relative to case-mortality, it was found that the treated cases recovered in greater numbers; and (4) the difference between the percentages of these two respective groups warranted the implication that serum-treated cases which survived the first ten days of illness had a better chance of life. In this series of cases, the method of injection employed was into the theca of the spinal cord after withdrawal of some cerebro-spinal fluid, but when injections were repeated frequently, or were relatively large in quantity, they were made into the subcutaneous tissues. It is to be noted, however, that the antisera at the disposal of these observers were not of so high specific value as, for example, the later antiserum of Flexner and Jobling. Flexner,[2] in the earlier stage of his preparation of an antiserum, employed rabbits, goats, and large monkeys, but in the later stage, the horse was employed. He found the rabbit to be a poor animal for the purpose, the goat to be fairly satisfactory, but the horse most satisfactory of all. Gardner Robb [3] has also reported on his experience of antiserum-treatment in the Belfast Hospital. Up till the end of May 1907, of 230 cases under his charge, the mortality was 70·4 per cent. By the end of August, the number had risen to 275, with a mortality of 72·3 per cent. Of the 230 cases, 79 were treated with the antiserum of Kolle and Wassermann, of Ruppel, or of Burroughs & Wellcome, but of these 79 the mortality was at the rate of 74 per cent. The results from this treatment being no better than those from ordinary treatment, it was discontinued. About the end of August the antiserum of Flexner and Jobling, prepared from a horse, was placed at his disposal, and 32 cases were treated with it. The results in 30 of these were that 8, or at the rate of 26·6 per cent., died, while the mortality of cases not in hospital, but treated in the city and without this antiserum, was 80 per cent. So far as these results go, they are most satisfactory, even allowing for the paucity of number treated. The amount of this antiserum employed varied in different cases from 30 c.c. up to 210 c.c., the method of injection being as already described. Robb inclines, from his experience, to the view that 30 c.c., or even larger doses, ought to be injected daily for three successive days. It would appear that the key to probable success in combating this most fatal disease lies, therefore, in the direction of antiserum-treatment. Whether such treatment is to attain any large measure of success remains for the future to determine, but if it can prevent the terrible calamity, in the form of complete blindness or loss of hearing, which has befallen some of the victims who have recovered, it will have achieved much.

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[1] *Lancet*, Oct. 10, 1908.

[2] *B.M.J.*, vol. ii., 1906, p. 1023.

[3] *Ibid.*, vol. i., 1908, p. 382.

Tetanus. This is due to the *B. tetani* of Nicolaier, which is an anaerobic organism. It measures from 1 μ to 2 μ in length, and by reason of its producing a spore only at one end is sometimes called the drumstick-shaped bacillus. It is a motile organism. It grows in anaerobic culture in glucose-gelatine media, and in the depth of a long stab culture of blood-serum or nutrient gelatine. The spores or organisms usually gain entrance to the body of a person through some wounded surface, the spores developing into full-grown organisms under anaerobic conditions at the place of inoculation. There, during their growth and multiplication, they develop a ptomaine or ptomaines which on being absorbed into the body produce the characteristic tetanic convulsive symptoms. From pure cultivations of the organism, Brieger[1] has been able to isolate different ptomaines, to which he has given the names of *tetanine, tetanotoxine* and *spasmotoxine*, The first gives rise to tetanus in animals, the second causes tremors and paralysis, succeeded by convulsions, and the third, tonic and clonic convulsions. The spores are mainly found in soils, but may also be found in other substances. For example, they exist in jute, doubtless due to soil-contamination. Between 1890 and 1899, eleven fatal cases occurred in Dundee, five of those attacked being workers in jute-mills, and three being children of workers in yarn-mills. Two cases occurred in 1899.[2] The spores have also been found in gelatine.[3] We know of at least three cases which arose after the use of surgical catgut, in which spores of the organism were found. Tetanus was also the result of injection of anti-diphtheritic serum in Italy in 1900, twelve persons having died, and several others having been dangerously ill. The serum was found to contain tetanus bacilli, the source of which was never positively discovered. The toxin of the disease may be extracted from the liver and other solid viscera of victims of the disease by the use of pure glycerine.[4]

The disease is most refractory to treat, and has a high mortality. Anti-tetanic serum has been used in several cases with successful and unsuccessful results. Baccelli treats cases with hypodermic injections of a 2 per cent. solution of carbolic acid in increasing doses and frequency. The dose administered in the first twenty-four hours is 3 grains of the acid, or 150 minims of the above solution, and is then rapidly doubled or trebled in amount, depending on the progress of symptoms. His results have been declared to be remarkably good.[1]

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[1] *Virchow's Archiv*, vol. cxii., p. 549; vol. cxv., p. 484.
[2] *B.M.J.*, vol. ii., 1900, p. 377.
[3] Tuck, *Jour. Path.*, 1903.
[4] Waring, *B.M.J.*, vol. i., 1902, p. 965.

Malaria. This polymorphic disease prevails very extensively throughout the world; indeed, it is known in both hemispheres, and in all continents. At the same time, it may be said to be limited in geographical distribution to a belt which runs round the globe between the fourth isothermal line north, and the sixteenth line south of the equator. Within the above area, its incidence depends upon the presence of rivers or stationary masses of water; thus, it is found to be endemic around low-lying, marshy grounds, in river-deltas, around lakes, and, indeed, wherever water is apt to lie upon the ground-surface. On the continent of Europe, it prevails in France, in the valleys of the Loire, its tributaries, and in those of the Rhone; in Germany, in those of the Rhine, Elbe, and other rivers, and along the Baltic coast-line; in Russia, along the course of the Volga, and on the banks of the Caspian Sea. It is found in nearly every province of Holland, in some parts of Belgium, Switzerland, in Sweden around Lake Wener, in Austria along the banks of the Danube; around the Black Sea; extensively in Southern Italy; and around the whole coast of the Mediterranean. It affects Southern Asia, includes the East Indies, but seems to be less prevalent in Japan. It is found in Northern Australia, many of the islands of the Pacific, but does not prevail in New Zealand or Tasmania. It is very prevalent in America along the Atlantic seaboard, around the great Canadian Lakes, and in New England, and it operates most harmfully on the populations of Southern American States, as Cuba, Mexico, and others. It is very virulent in all parts of Africa, except, perhaps, the extreme south. In England, it used to prevail in the fen-districts of Norfolk, Cambridge, Somerset, Kent, and others, and in Scotland, in the Carse of Gowrie and the valleys and courses of the larger rivers. It does not appear to have ever been present to any extent in Ireland. It does not exist in endemic form in any part of Great Britain at the present day. Since the time of Hippocrates, who was familiar with its clinical characters, many theories as to its prime cause have been promulgated. Known to be intimately associated in some way with stagnant marshy waters, it was believed in some way to be due to conditions of soil. Later views, however, associated the cause with infusoria, poison secreted by marsh animalcules, cells of water-plants, etc., until, in 1879, Klebs and Tommasi-Crudelli attributed it to a microbe, to which they gave the name of *B. malariæ*. In November, 1880, Laveran, a French surgeon in Algiers, when making microscopic examination of the blood of a soldier who was suffering from ague, discovered the presence of bodies with which hitherto he was unacquainted. By further examination and observation he arrived at the opinion that these might be the cause of the disease. The significance of Laveran's corpuscles, however, was not appreciated at the time, nor indeed for some time afterwards. It was not till 1895 that further progress in the solution of the cause was made. Manson, doubtless prompted by his discovery of the propagation of Filariasis by means of the mosquito, suggested to Ross, an Indian army surgeon then about to proceed to India, a line of research in this direction. For two and a half years Ross examined many mosquitos without any reward, but at the end of this time at Sigur Ghat, near Ootacamund, he noted for the first time a mosquito which had spotted wings. Capturing eight of them, he set them to feed on the blood of a malarious patient, and at varying intervals of time thereafter, he dissected their bodies and examined them microscopically. The first six showed negative results. In the seventh, however, he observed some unusual cells on the outer wall of the stomach, which contained granules of melanin—the black colouring matter of the blood; in the eighth, he found like cells in the same position, but larger. At this stage, however, his malarial investigations were terminated by reason of the outbreak of plague in other parts of India, which required his services. During this time, however, in his spare moments, he worked at the life-history of similar organisms in the blood of birds. The following is a summary of Ross's discoveries in birds: When he fed mosquitos on the blood of birds containing this hæmatozoon—called by Labbé *halteridium*—he found in the stomachs of the insects the pigmented cellular bodies which he had seen in mosquitos that had been fed upon human malarial blood, but if the blood of birds contained no hæmatozoon, no such bodies were found in the mosquito. He noted the gradual development of those pigmented cellular bodies on the outer surface of the stomach-wall, where they formed wart-like projections to which he gave the name of *proteosoma-coccidia*,—but which may more properly be called *zygotes*,—until they matured and ruptured, throwing large numbers of small falciform bodies into the body-cavity of the insect. He further watched the progress of these bodies—called by him *germinal rods*—towards the veneno-salivary glands, ducts, and proboscis of the insect, and thus established the cycle of development of the avian parasite within the mosquito. The Italian observers, Grassi, Bastianelli, Bignami, Celli, Golgi, and others took up the work at this stage, and continued it. The combined observations of these men, of Koch, and many others have practically completed the life-history of the blood-parasites of malaria. While similar parasites attack birds, cattle, monkeys, and frogs, it is now well established that three different species of hæmatozoa live in the blood of man, corresponding to the three main forms of malarial fever, viz.: the tertian, quartan, and æstivo-autumnal or pernicious types. To the hæmatozoon of the first, Ross has given the name *Hœmamœba vivax*; to that of the second, *Hœmamœba malariæ*; and to that of the third, *Hœmomenas prœcox*. These belong to the *Protozoa*, order *Sporozoa*, the characters of which are as follows, viz.: (1) they are parasites, and are represented by true cellular elements; (2) the cells consist of protoplasm, a nucleus, and a nucleolus or karyosoma; (3) the cells are true endocellular parasites or cytophages; (4) they possess a free amœboid phase of existence; (5) they multiply by spores. The Sporozoa embrace the following sub-orders: (*a*) *Microsporidia*, of which the corpuscles of Cornalia in silkworm disease may be taken as a type; (*b*) *Sarcosporidia*, of which Miescher's corpuscles found in the muscle of frog, sheep, pig, and ox are examples; and (*c*) *Coccidia*, which give rise to infections in rabbit, cat, mouse, ox, and man. In 1882, Pfeiffer found that in the development of the coccidium there was alternation of generation, a phase in one animal in which the parasite is endogenous and asporular, and another, in a second animal, in which it is exogenous and sporular. In 1887, Metschnikoff affirmed the view that the malarial parasite was related to the coccidium. The life-story of the malarial parasites is as follows: the organism—an amœba—called an *amœbula*, enters a human red blood-corpuscle, begins to grow rapidly at the expense of the corpuscular contents, and assimilates the hæmoglobin which it converts into *melanin*, until it finally monopolises the corpuscular body. At this stage one of two things happens, viz.: either the amœbulæ become *gametocytes*, that is, uniting cells, or they become *sporocytes*, or spore-bearing cells. In the latter case, the nucleus of the amœbula subdivides into a number of smaller nuclei round each of which protoplasm forms, each to become a spore. When this process is complete, the corpuscular wall ruptures, and the spores and melanin-granules are shed into the blood-stream, the former to re-attack fresh corpuscles as amœbulæ, the latter to be absorbed by the leucocytes, and to be borne to such internal organs as spleen, liver, brain, etc., where the pigment is deposited. In this way the process goes on repeating itself. It was not until 1885 that Golgi—an Italian observer—described this phenomenon of sporulation, showed that the spore-distribution in the blood-stream was contemporaneous with the attacks of fever, and further pointed out that at this stage the exhibition of quinine was likely to be most effective. In the tertian type—usually the most common—the *H. vivax* passes through the above stages in man in 48 hours, and thus the outbreaks of fever appear every second day, or the third day if the day of the former attack is reckoned as the first; in the quartan type, the parasite sporulates in 72 hours, the attack recurs every third day, or fourth day if reckoned as above. It sometimes happens, however, that two crops of parasites in the tertian type come to maturity on alternate days, hence the attack occurs daily, and is then designated as quotidian fever. In the æstivo-autumnal or pernicious type, the symptoms are markedly different from the others, and do not exhibit the same periodicity—although the parasite matures every 48 hours. The foregoing, therefore, represents the endogenous phase of existence of the malarial parasite. The other form of cell is the *gametocyte*. If such cells be removed in the blood-corpuscles from a patient and placed on a warmed slide, it may be observed that certain of them throw off filiform bodies. This phenomenon, however, does not take place within the body of man. In 1897, M'Callum of Baltimore showed from his investigations that there were two kinds of gametocytes, viz. (*a*) those which produced the filiform bodies—the male gametocytes or *microgametocytes*,—and (*b*) those which do not undergo any such change—the female gametocytes, or *macrogametocytes*. As soon as malarious blood is sucked into the stomach of the mosquito, the microgametocyte bursts, the filiform bodies or spermoids are liberated, enter the macrogametocytes and fertilise them, and from the union new bodies are formed which individually are called a *zygote*. In the stomach of the mosquito, then, the zygote travels to the walls of the organ, pierces the inner coats, and as soon as it reaches the muscular coat begins to grow, so that at about the end of a week it is about 500 times its original size. If the zygote be now microscopically examined, it will be found divided up into eight or ten actiniform bodies called *meres*, from the periphery of which a large number of filiform bodies or *blasts* are formed. As the zygote matures, it increases in size, until it finally bursts and its contents are thrown off into the body-cavity of the insect—that is, into the space between the stomach-wall and the body-wall. These blasts make their way—whether by their own motile power or not is not yet known—into the cells of the veneno-salivary glands, thence into the salivary ducts, then into the biting parts of the insect, so that when the insect bites a human being they enter into the blood-stream. The following diagram shows the two phases of the life-history of the parasite :—

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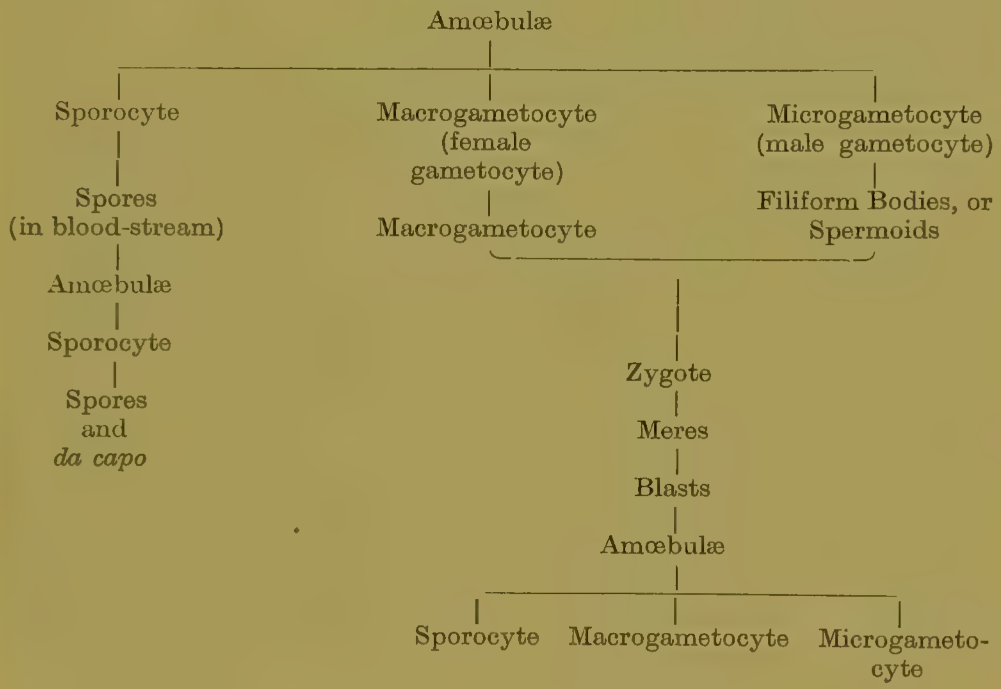
[1] *Brit. Physician*, Sept. 15, 1899, p. 75.



It next remained to discover whether all mosquitos were capable of acting as definitive host to the malarial parasites. To this point much research has been given, and, so far as has been ascertained, it seems well established that only certain insects of the genera *Anopheles* and *Culicidæ* are so capable, and that if the malarial parasites are taken into the bodies of other insects of these classes, they are either digested or are disintegrated, as they certainly do not undergo development. The insects of the genus *Anopheles* which have been proved to act as definite hosts of the human parasite are the *Anopheles maculipennis*, which is called by the Italians *A. claviger* (Fabricius), by Americans *A. quadrimaculatus*, and in Africa the *Anopheles funestus*.[1] The descriptive names of the first three owe their origin to the presence of four dark spots upon the wings, which are most conspicuous in the female insect.

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[1] *B.M.J.*, vol. i., 1901, p. 193.

Culex pipiens of the genus *Culicidæ* is the insect by which, so far as is known, the parasite of birds is transmitted and matured. Experiments have demonstrated that this insect fails to carry the human parasite, and *A. maculipennis*, the avian parasite.

In order to demonstrate the correctness of the above views, observers have submitted themselves to experiments. Insects which were fed on the blood of a person suffering from pure benign tertian ague in Rome were transmitted under suitable precautions to London, and were there suffered to bite and feed upon the blood of persons free of malarial infection, with the result that the persons experimented upon were attacked by the same disease, as proved not only by the clinical symptoms, but by the discovery of the parasite in their blood.[1] Fearnside of the Indian Medical Service suffered himself to be bitten by mosquitos which were fed on the blood of a person known to be affected with spring tertian fever, and was seized with the disease in due course, the hæmamœbæ being found in his blood.[2]

Prevention of Malaria.—This can only be attained by the adoption of various preventive measures, which are included in the following—viz. (1) Attack upon the breeding-grounds of the mosquitos involved; (2) The use of mosquito-proof dwellings; (3) The liberal preventive and curative use of quinine.

I. *Attack upon Mosquito Breeding-Grounds.*—The *Anopheles maculipennis* and *Culex pipiens* deposit their eggs in water which is either slightly moving or is stagnant. The former prefers clear moving water. The latter is not so particular, as any stagnant puddle of water or water retained in vessels will suffice. The first remedy must, therefore, consist in deep draining and cultivation of marshy lands, so that surface water may be prevented from collecting and may be enabled to pass away by the underground drains. It is probably for this reason chiefly that malaria has ceased to be an endemic disease in Britain. In the smaller towns and villages of malarious districts attention must also first be paid to surface-drainage, and water must not be allowed to remain in vessels during the mosquito breeding-season for so long a time as will enable the eggs to develop through the larval and pupal stages into the complete insect. Obviously, however, this measure can only be limitedly applied, as it would be impossible to drain the borders of marshy lakes; and it would put an end to the rice-growing industry. In such cases, and even also where surface-water is conveyed by artificially-constructed channels to a river, some other measure of destruction of eggs and larvæ must be instituted, as, for example, the introduction of such fishes as feed upon stream larvæ and insects, or the addition to the water of such substances as will destroy the larvæ. From the experiments of Celli and Casagrandi it is evident that substances which act destructively upon the larvæ operate in one of two ways, viz.: either by rendering the water sufficiently poisonous, or by preventing the larvæ from breathing. During the larval state both *A. maculipennis* and *C. pipiens* breathe by means of breathing organs which are projected just above the water-level; therefore it has been proposed to put in the water an oily substance such as petroleum, which by forming a film on the water-surface prevents their respiratory action. These observers have found this latter method efficacious when the petroleum was present in the proportion of 1 cubic centimetre to 1000 cubic metres of water-surface. This is probably the cheapest mode of destroying the larvæ, and it has proved effectual in many practical trials. Certain of the anilin dyes mixed with water are also very destructive to larvæ; and of these *gallol* and *malachite green* have been found efficient, the former in the proportion of 0·0062 per cent., and the latter, of 0·0125 per cent.

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[1] *B.M.J.*, vol. ii., 1900, p. 949.

[2] *Indian Med. Gazette*, 1901.

II. *The Use of Mosquito-proof Dwellings.*—Experiments in the Campagna with a mosquito-proof hut showed that persons might live with impunity in the most malarious districts, provided that they took the precaution not to be out-of-doors after sunset or before sunrise. This remedial measure can, however, have but a very limited application. It is, at the same time, one worthy of practice by Europeans who are compelled temporarily or permanently to live in malarious regions. Another important precaution is where on expeditions tents have to be put up, that these should be erected at least 600 to 800 yards from native quarters. This is suggested because it has been found that mosquitos take refuge during the day in the darkened corners of these huts, and because experience has shown that the average mosquito flight does not extend that distance, and that even in windy weather, when the insects might be blown for longer distances, they commonly seek shelter and thus do not reach the tents.

III. *The Use of Quinine.*—As a preventive measure quinine should be taken periodically. As a curative measure, its use is most effective during the paroxysms of fever, since, as has been pointed out, it is then that spores are liberated from the sporocytes into the blood.

Glanders is mainly a disease of horses, asses, and mules. When it appears in a stud it quickly spreads, and the affected animals must according to law be destroyed. It is communicable from animal to man both by contagion and by direct inoculation. When the disease attacks man it ordinarily ends fatally, as in the case of Dr Hoffmann of Vienna in 1889. Another fatal case occurred in Glasgow in 1901, and a third in England in 1889.[1] Its causal factor is the *B. mallei*, which is a rod-shaped organism, one end of which is more thickened or clubbed than the other, and which is non-motile and non-sporular. It does not take the stain by Gram's method, but stains well with Löfflers' methylene - blue or with carbol - methylene - blue. The organisms are found in the discharges from the nose of the affected animal, in the small grey bodies which are found in the respiratory passages, and in the ulcerated bronchial mucous membrane; or in the nodules in the skin and subcutaneous tissue, known in veterinary practice as farcy buds.

That glanders is not an uncommon disease in this country among horses is shown by the fact that from 1881 until the commencement of 1906, no fewer than 44,943 horses had been returned as having died or were dying from the disease, or on an average of about 2000 animals per annum. Glanders has been a disease scheduled under the Contagious Diseases (Animals) Act, since 1869. The typical clinical symptoms in the horse are (1) enlargement of submaxillary glands, (2) nasal discharge and ulceration of mucous membrane of the nares, larynx, and, it may be, the trachea, (3) enlargement of lymphatic glands and vessels with small tumours under the skin, called "farcy buds"—hence the designation of the disease, glanders and farcy—and (4) swelling of one or more of the limbs. The most constant lesions found in the post-mortem examination of the bodies of such animals are nodules in the lungs, which, when microscopically examined, exhibit necrotic areas and abundance of the bacilli. According to a report by the Veterinary Inspectors of the London County Council of 1000 such post-mortem examinations, the lungs in every case were so affected, and, in addition, in 378 of these cases there was ulceration of the nasal mucous membrane, in 179 ulceration of the larynx, and in 201 ulceration of the trachea. Mallein was first discovered in 1890 by a Russian veterinary surgeon. It has proved of very great value in determining the existence or absence of the disease in those cases which clinically are indeterminate and doubtful, or in which the disease is latent. When injected into the body of such animals, and when the disease is present, a reaction takes place which is indicated by the formation of a swelling at the seat of injection, and by a characteristic sequent rise of temperature. The blood of the animal thereafter acquires an agglutinative power over the organism, as in Widal's reaction. At one time it was supposed that mallein had some curative value, but that was not proved to be well founded.

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[1] *Lancet*, vol. ii., 1889, p. 127.

Mallein is a vaccine or toxin prepared from the *B. mallei*. The organism is cultivated in veal-broth in a flask, and the flask is placed in the autoclave at 115° C. for fifteen minutes to destroy the bacilli. The broth is then filtered through a Berkefeldt filter. The filtrate is concentrated to one-fourth its original bulk, and 0·5 per cent. of carbolic acid may be added to preserve it. Of this 1 c.c. is a good dose.

The disease is very difficult to diagnose in the human subject, and not infrequently it is mistaken for another disease, such as enteric fever. Goodall of the Eastern Isolation Hospital, London, has had two such cases. In the one case the presence of intramuscular abscesses, which are pathognomonic of glanders but are never found in enteric fever, gave the real clue to the disease, and in the other, the nature of the man's occupation supplied the clue. Other cases have been admitted to other hospitals also under mistaken diagnoses. In August, 1907, the Scottish Local Government Board issued a circular to Medical Officers of Health requesting them in the future to intimate to the clerk of the town or county as clerk to the Local Authority under the Contagious Diseases (Animals) Acts, any case or suspected case of glanders, anthrax, and hydrophobia in man which came to their knowledge.

The Board of Agriculture issued the Glanders and Farcy Order of 1894 in which the following regulations were set down :—(1) that the owner of a glandered animal shall notify the fact to a constable of the Local Authority, who, in turn, shall inform the inspector to the Local Authority under the Contagious Diseases (Animals) Acts ; (2) that the inspector shall proceed forthwith to the place and there put in force the duties and powers conferred on him by the Order ; (3) the animal, with the consent of the owner was to be destroyed, but if the owner objected, then only after consent of the Board ; (4) the Local Authority was to pay compensation to the owner of the slaughtered animal, the minimum amount to be £2, and the maximum, one-fourth of the value of the animal before it became diseased. Article 6 of the Order empowered the Local

Authority to make regulations, as they thought fit, for prohibiting the movement of diseased or suspected or contact animals, but in respect of contact or infection-exposed animals the movement was only to be prohibited when the building or other place to which restriction applied contained an animal held to be actually diseased. Article 9 made it illegal to expose any diseased or suspected animal in any public place, to graze such animal on pastures by the sides of highways, or to carry, lead, or drive any such animal on a highway or thoroughfare; and Article 8 made provisions as to disinfection.

This Order was superseded, however, by the Glanders and Farcy Order, 1907, No. 7322, which came into operation on 1st January 1908.

Foot-and-Mouth Disease.—This disease, which is known also by the synonyms "*epizootic vesicular stomatitis*," "*Aphtha epizootica*" and "*vesicular murrain*," is also transmissible to man. Hirsch[1] attributes the first record of it to Sagar, an Austrian physician, who gave an account of a seizure in Moravia in 1764. The *materies morbi* may be transmitted to man either from the products of the cow—milk, butter, or cheese—or from the absorption into the body of man by some accidental raw surface of the discharge, buccal or nasal, of an affected animal. There can be little doubt that the disease is of microbial origin, although, so far as we know, no specific micro-organism has yet been isolated. The symptoms of the disease in man resolve themselves into the exhibition of general febrile disturbance, affection of the mucous membranes, and the appearance of a cutaneous eruption. The eruption on the skin is mainly confined to that of the hands and feet, but in certain cases it has appeared more generally all over the body-surface. In a case which we recorded,[2] the disease was heralded by fever, severe conjunctivitis, and some coryza and a slight cough. A rash appeared on the face and neck which looked not unlike the initial stage of measles. The conjunctivitis increased, as did also the coryza, and the nasal mucous membrane became swollen, but the rash on face and neck cleared away. Then the mucous membrane of the mouth became swollen, inflamed, and tender, and bore the appearance generally as if it had been painted over with blistering fluid. Swallowing became, in consequence, painful and difficult. A rash now began to develop on the forearms and on the palms of the hands and soles of the feet. On the forearms it consisted of circular and oval papules, and on the palmar and plantar skin as circular papules of a pinkish colour. These papules gradually developed into vesicles. By this time, distinct vesicles were found plentifully in the mouth and over hard and soft palate. These ruptured and developed into angry and raw ulcers of varying size and depth, which were not quite healed until about the end of the fifth week of the illness. The rash on the hands and feet went through the stages of papule, vesicle, and pustule. After the fluid contents of these were absorbed, desquamation of a free character followed. The late Dr J. B. Russell saw the case with us, and agreed in the diagnosis. No evidence was obtainable of the existence of disease in the dairy-farms around Glasgow at this time, and the patient had no connection in any way directly with cows. Several other cases have been recorded. Cases were common for example in the human subject during the epidemic among cattle in Germany in 1838. As in the paper noted we have dealt with the literature of recorded cases, the reader who desires to pursue the subject further is referred to that paper.

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[1] *Geographical and Historical Pathology*, vol. iii., p. 241. (New Syd. Soc. Ed.)

[2] *Lancet*, 26th Sept. 1896.

Foot-and-Mouth Disease is one of the diseases named in the Contagious Diseases (Animals) Acts (*vide postea*).

The Foot-and-Mouth Disease Order of 1895 regulates the actions of Local Authorities and inspectors and owners respecting any outbreak of the disease, relative to (*a*) giving notice of cases of the disease, (*b*) duties of inspector on receipt of such notice, (*c*) rules to be applied to the infected place, (*d*) removal of infected things, (*e*) prohibition of movement of animals, (*f*) disposal of carcases of infected animals, and (*g*) disinfection.

Anthrax or **Splenic Fever** of cattle, sheep, goats, pigs, deer, horses, and other animals, and wool-workers' disease, or malignant pustule —its synonyms in man—is a very fatal disease. In man, its constitutional or pulmonary form, which is known as wool-sorters' disease and was first recognised in England in 1879, is usually induced by inhalation of spores of the bacillus, and mainly affects the lungs. Malignant pustule is an external local manifestation of the disease due to direct inoculation of a wounded point with the specific micro-organism. The first published account of malignant pustule in England is dated 1863, although it was known before this time. It appears to be endemic in Cyprus due to the sting of the insect Sphalangi. It is a disease, therefore, which is communicable from animals to man. The disease was well known in animals before its communicability to man was dreamt of. Its connection with man was first discovered when an investigation was made by Dr Bell of Bradford into a strange disease which broke out among wool-sorters in that town. It has also been seen many times among hair-sorters since. Workers among hides and hoofs are liable to be attacked with the external form of the disease, if the materials have been taken from diseased animals. The pustule or boil which forms by inoculation on the skin begins at first as a small inflamed vesicle or pustule, which becomes black, and is surrounded by a thickened brawny area of tissue from which pass inflamed lymphatic vessels. It may end in resolution, or the central black necrosed tissue may slough out with suppuration but with little accompanying constitutional mischief, or on the other hand, the pustule may be the source of profound constitutional disturbance.[1]

Of 1077 cases collected by Koch, in 490 the pustule occurred on head and face, 45 on neck, 370 in the upper limbs, and in the remaining cases on other parts of the body.[2] The disease is caused by the *B. anthracis*, a rod-shaped organism, which varies from 2 to 10 micro-millimetres in length, and from 1 to 1·5 in breadth. It stains freely by Gram's method. It is non-motile, sporulates freely, and its spores are among the most resistant to destructive agents. All parts of an infected animal carry organisms, hence blood-smeared hides, hair, or hoofs, when dry, convey the disease. The dust contains the spores. During life, it is conveyed from animal to animal by direct or indirect contagion, by the association of the infected and non-infected, and also by infected

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[1] *B.M.J.*, vol. ii., 1901, pp. 133 *et seq.*

[2] Treves's *Surgery*, vol. i., p. 313.

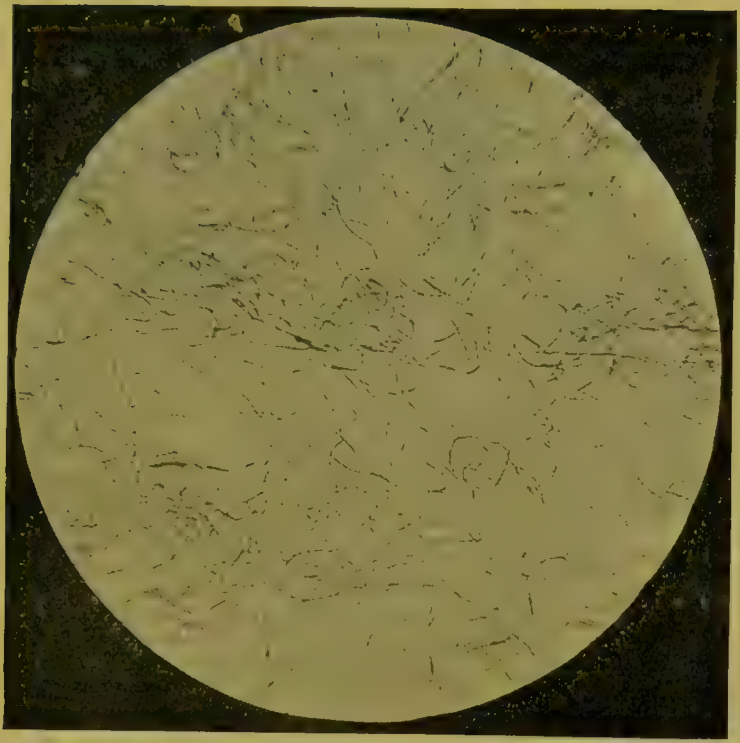

FIG. 114.—Photo-micrograph of pure culture of *B. anthracis.* ×600 diameters. (Author.)

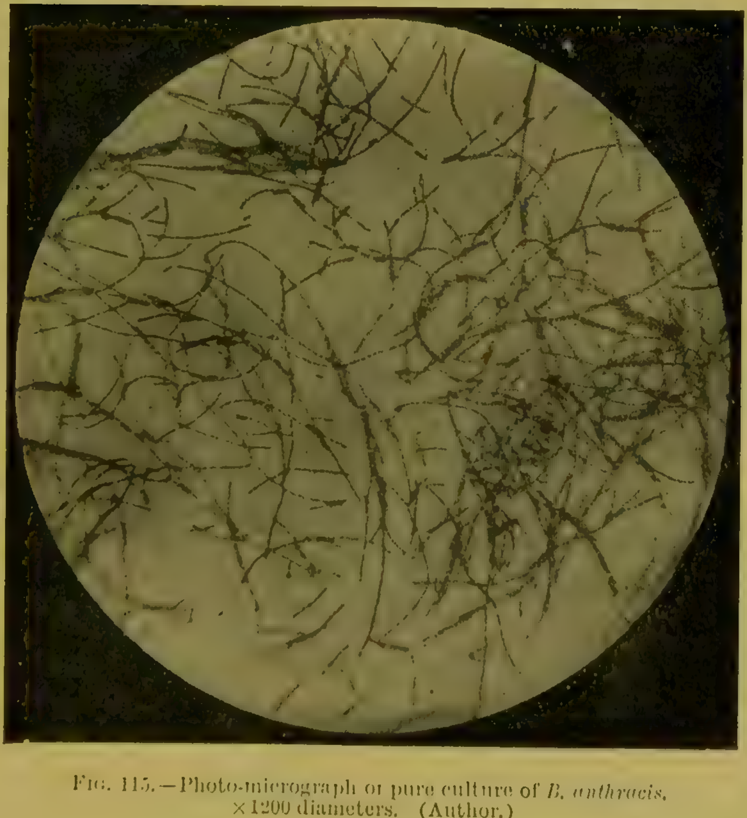

FIG. 115.—Photo-micrograph of pure culture of *B. anthracis.* ×1200 diameters. (Author.)

public watering-troughs. The disease is believed also to have been conveyed by infected oats and oil-cake. In the Queen's Bench Division, judgment was given for a defendant who resisted payment of a bill for oats supplied to him, on the ground that the oats had caused anthrax among his horses. The jury awarded him damages for the horses which had died.[1] In another case, it was proved that the disease had been transmitted to oxen by means of oil-cake. In wool-sorting and hair-sorting factories precautions must be taken to protect the employés, either by steeping in disinfecting solution the materials to be handled, or by instituting bench-ventilators to carry away dust, and by providing muzzles which are to be worn by the workmen. In 1899, the Board of Agriculture issued the Anthrax Order for England (No. 5905), under which cases of this disease in animals are dealt with, the owner being compelled to report their existence to the inspector, who in turn must inform the Medical Officer of Health.[2]

Contagious Diseases (Animals) Acts

The Diseases of Animals Act, 1894, consolidated the Contagious Diseases (Animals) Acts, 1878–1893, except the provisions of those Acts which relate to dairies, cowsheds, and milkshops. (*Vide* p. 420.)

Since the passing of this Act, the following further Acts have been passed :—

1. The Diseases of Animals Act, 1896;
2. The Diseases of Animals Act, 1903; and
3. The Diseases of Animals Act, 1909.

These Acts are administered under the supervision of the Board of Agriculture and Fisheries.

The diseases named in the Act of 1894 are (1) cattle-plague, (2) pleuro-pneumonia, (3) foot-and-mouth disease, (4) sheep-pox, (5) sheep-scab, and (6) swine-fever; by section 10, the Board are empowered to make such orders as they think fit for prescribing the cases in which places may be declared to be infected with the disease other than those specifically named.

The objects of this Act are mainly as follow :—

1. To secure that due notice shall be given by every person of any animal under his charge affected with any of these diseases;
2. To secure, so far as practicable, isolation of affected from healthy animals;
3. To prevent the movement of animals from any infected place or area. Where a place is declared infected, the whole space lying within half-a-mile from any part of such place shall become and be a circle infected with that disease;
4. To give compensation to owners for animals slaughtered which are diseased or infected;
5. To make provisions respecting the case of animals affected with any of the aforenamed diseases, while (*a*) exposed for sale or being exhibited in any market, fair, exhibition, or (*b*) in transit, or (*c*) in a foreign animals or quarantine station, or slaughter-house, or not under control of owners;

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[1] *Lancet*, vol. ii., 1895, p. 1517.

[2] Revoked by Anthrax Order, 1910. (*Vide* Appendix, p. 567).

6. To empower the Board to make orders respecting any matters relating to infected animals, infected places, infected things, the extension of the definition of "disease" in this Act, with the supply of food and water to animals at railway-stations, the slaughter of all foreign animals at ports of landing, and many other matters.

The Local Authorities in Scotland under this Act are the magistrates and town councils of each burgh not being a burgh to which section 14 of the Local Government (Scotland) Act, 1889, applies; and the County Council for each county and council of any burgh to which said section 14 applies, and any royal burgh which does not return or contribute to return a member of Parliament. Section 14 referred to enacts that where a burgh contains a population of less than 7000, the powers, duties, and liabilities of the magistrates and town council of such burgh under the Contagious Diseases (Animals) Acts shall cease, and shall be vested in the County Council.

The Diseases of Animals Act, 1896, is a short amending Act, and the Act of 1903 amends the Act of 1894 in relation to sheep-scab. It empowers a Local Authority to provide and maintain portable fitting tanks, and, with the sanction of the Board, dipping-places for sheep, and to afford the use of the same, upon such terms as the Local Authority may think fit; but no dipping-place shall be used if such use would injuriously affect the water in any stream, reservoir, aqueduct, well, pond, or place constructed and used for the supply of water for drinking or other domestic purposes.

The Act of 1909 is an Act authorising the payment of fees to veterinary surgeons and practitioners for notification of diseases of animals.

The Board issued the Animals (Notification of Disease) Order of 1910, in view of that Act. The diseases to which this Order applies are :—cattle-plague, pleuro-pneumonia, foot-and-mouth disease, sheep-pox, sheep-scab, swine-fever, anthrax, epizootic lymphangitis, rabies, glanders and farcy. It ordains that a veterinary surgeon shall, with all practicable speed, give notice of the existence or the suspected existence of any of these diseases to an inspector of the Local Authority, and also, except where the disease is anthrax, sheep-scab, glanders or farcy, to a local constable, who shall by telegram transmit the information to the Board of Agriculture, London. The inspector, on receipt of any such notice, shall forthwith report the same to the Local Authority, and if the disease is anthrax, glanders or farcy, also to the medical officer of health of the district in which the animal or carcase is. The fee paid to the veterinary surgeon for each notification is 2s. 6d., except that where more than one animal is affected in the same place at the same time only one fee shall be paid.

Tuberculosis is a disease common to man and many of the lower animals which is produced by the *B. tuberculosis.* The organism measures on the average about 2·5 micro-millimetres in length, about ·2 to ·3 in breadth, and in form is slender and slightly curved. In cultures the bacilli are often shorter and thicker than those seen in phthisical sputum. They sometimes exhibit a well-marked beady appearance. In older cultures one end may appear clubbed, or branched, which latter appearance is not infrequently seen in avian tubercle. It is believed by certain observers that this bacillus is but one form of a pleomorphic mould related to actinomyces, and is not a true bacterium. The organism in sputum stains well, however, by Ziehl-Neelsen's method; that is, with carbol-fuchsin first, which stains the bacilli red, then with Löffler's methylene-blue, which stains the sputum itself blue. Whether the bacillus is spore-bearing or not is still an open question.

Phthisis pulmonalis may be considered to be a contagious, and an infectious disease. In cases where contagion has been proved, two conditions have been found to prevail—viz. insanitary environment and propinquity of persons, as in the relationships of husband and wife, sisters, or brothers, who occupy the same beds. The old doctrine of hereditary transmission must be put aside, but while the disease itself is not transmissible, its predisposition is. Malvez and Browvier demonstrated the presence of tubercle-bacilli in a calf fœtus of eight months which was found in the uterus of a tuberculous cow.[1] Pulmonary phthisis must largely have its origin in dried tubercular sputum, which, inhaled by susceptible persons, finds in them a suitable breeding-ground. The bacillus is found in enormous numbers in the sputum of those suffering from advanced phthisis.

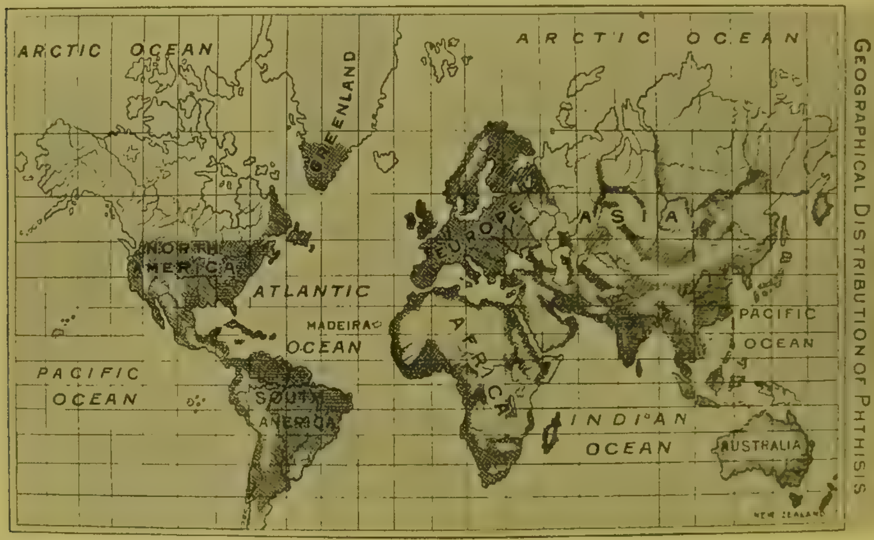

FIG. 116. Illustrates the Geographical Distribution of Phthisis in the World. By the lightness or darkness of the hatching is the measure of intensity of the disease indicated. (*Vide* Ransome's Milroy Lectures.)

Tubercular disease presents itself in the human subject in other forms than the pulmonary; for example, as *Tabes mesenterica*, and *tubercular meningitis*. The source of infection in the former class of cases is believed to be tuberculous milk. This is not impossible, since the milk of cows suffering from tuberculous udders contains bacilli in abundance. Another possible source of the disease in young persons and adults is the ingestion of imperfectly-cooked tuberculous meat. Opinion is much divided on this point. Some are of opinion that limited tubercular lesions present in the body of an animal render its flesh wholly unfit as human food; others, that if the limited lesions be extirpated, the rest of the carcase may be safely used. The former view was expressed by the Congress on Tuberculosis held in Paris, the latter by the Victorian Commission and by the Royal Commission on Tuberculosis of 1898 in its Report. By reason of this difference in expert opinion, the policy of Sanitary Authorities on this point has been divided. In Berlin a middle course is adopted. By a Ministerial Decree of 1892, it was enacted that when the carcase of an animal exhibited general tubercular affection the whole carcase was to be condemned; where, however, one organ only, or two organs lying contiguous in the same bodily cavity were affected, the carcase was not to be deemed unfit for human food, but to be considered as flesh defective in quality. It was then thoroughly cooked under police supervision and sold at a reduced price. Such a course is at once reasonable and safe from all points of view.

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[1] *Lancet*, vol. i., 1889, p. 115.

The following are the Recommendations of the Royal Commission on Tuberculosis, 1898:—

“C.—TUBERCULOSIS IN ANIMALS INTENDED FOR FOOD

“6. We recommend that the Local Government Board be empowered to issue instructions from time to time for the guidance of Meat Inspectors, prescribing the degree of tubercular disease which, in the opinion of the Board, should cause a carcase, or part thereof, to be seized.

“Pending the issue of such instructions, we are of opinion that the following principles should be observed in the inspection of tuberculous carcases of cattle:—

“(*a*) When there is miliary tuberculosis of both lungs	The entire carcase and all the organs may be seized.
“(*b*) When tuberculous lesions are present on the pleura and peritoneum	
“(*c*) When tuberculous lesions are present in the muscular system, or in the lymphatic glands embedded in or between the muscle . .	
“(*d*) When tuberculous lesions exist in any part of an emaciated carcase	
“(*a*) When the lesions are confined to the lungs and the thoracic lymphatic glands . . .	The carcase, if otherwise healthy, shall not be condemned, but every part of it containing tuberculous lesions shall be seized.
“(*b*) When the lesions are confined to the liver .	
“(*c*) When the lesions are confined to the pharyngeal lymphatic glands	
“(*d*) When the lesions are confined to any combination of the foregoing, but are collectively small in extent	

“In view of the greater tendency to generalisation of tuberculosis in the pig, we consider that the presence of tubercular deposit in any degree should involve seizure of the whole carcase and of the organs.

“In respect of foreign dead meat, seizure shall ensue in every case where the pleuræ have been ‘stripped.’”

Since it is the commonly accepted opinion that the propagation of tubercular disease among infants and young children is to be largely attributed to tuberculosed milk, precautionary measures must be adopted to prevent the sale of such milk. It is notorious that cows confined to sheds in towns and cities are highly tuberculous. Various factors contribute to this, more especially perhaps, want of an open-air life and the existence of insanitary environment. Hence the necessity for such constant and careful supervision of cows in town cowsheds by Sanitary Authorities as is prevalent in certain cities in Denmark and elsewhere. In the Dairies, Cowsheds, and Milkshops Order, 1899, issued by the Local Government Board of Scotland, article 15 of the Order of 1885, which stated that "if at any time disease exists among cattle in a dairy or cowshed or other building or place, the milk of a diseased cow therein (1) shall not be mixed with other milk; (2) shall not be sold or used for human food; and (3) shall not be sold or used for food of swine or other animals unless and until it has been boiled" was changed, so that the word "disease" therein should be held to include such disease of the udder of a cow as is certified to be tuberculous by a veterinary surgeon. The Board drew the attention of Local Authorities to the recommendations of the Commission on Tuberculosis respecting cowsheds, in framing Dairy Regulations under the Order of 1899. The conditions laid down by the Commission for attached cowsheds in a populous place as entitling to registration of a dairy, are as follow — viz. (1) an impervious floor; (2) a sufficient supply of water for flushing purposes; (3) proper drainage; (4) a depôt for manure at a sufficient distance from the byres; (5) a minimum cubic space of from 600 to 800 feet for each adult beast, varying according to the average weight of the animals; (6) a minimum floor-space of 50 feet for each adult beast; and (7) sufficient light and ventilation. Such regulations as the foregoing are intended to maintain average healthy surroundings for healthy animals. But if tuberculosis in cattle is to be abolished, steps must be taken prior to this to apply such tests as will weed out animals already affected. For the purposes of public safety, probably it would be enough to secure that no animal with a tuberculous udder should be permitted to give milk to be used for human food. Local Authorities, as Manchester, seek, however, to prevent the sale of tuberculous milk by submitting samples to bacteriological examination. Delépine has given

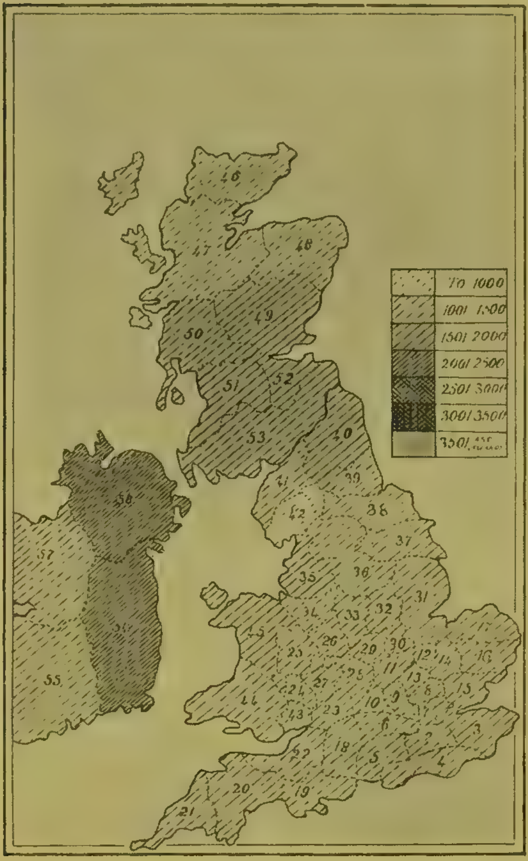

FIG. 117.—To illustrate the relative incidence and prevalence of Tuberculosis in Great Britain and Ireland. By reference to the key the number of deaths per million of population living may be ascertained.

a Table which illustrates the incidence of the tubercle-bacillus in Manchester milk-supplies[1]:—

TABLE XL

Source of Milk	No. of Samples Examined	No. found Tuberculous	Percentage of Tuberculous Samples
A.—*Mixed Milk*, from town or country dairies, collected at the farms, at railway-stations, or in town dairies	693	79	11·37
B.—*Unmixed Milk*, obtained direct—			
1. From healthy cows .	18	. .	. .
2. From cows diseased, or not stated to be healthy . . .	178	31	17·36[2]
	889	110	. .

Prophylaxis of Tuberculosis of Bovine Animals.—There are probably few observers who have given more attention to the subject of bovine tuberculosis than Bang of Copenhagen. In a communication to the Paris Congress of 1898, he gave some interesting figures as to the extent the disease prevailed in cattle. Of animals slaughtered for human food whose carcases were found to be tuberculous, the percentage number in Baden was 3·57 per cent., in Bavaria 5 per cent., in Hamburg 8·56 per cent., in Prussia 12·7 per cent., in Saxony 27·5 per cent., and in Zwickau 37·5 per cent. During the years 1895 and 1896, the positive reactions to the tuberculin test yielded by animals were 37·2 per cent. and 41·9 per cent. respectively. In Vienna, from 1893 to 1895, the number of tuberculosed carcases found on slaughter was only 1·30 to 1·80 per cent., owing, it was believed, to the fact that the bulk of the animals came from Hungary where tuberculosis is not rife. In France, a similar irregular distribution of tuberculosis among animals was found. In Toulouse, in 1889, the percentage of tuberculous carcases of the animals slaughtered was 9·28 per cent., and in Brie and Beauce, about 25 per cent. In Belgium, in 1896, the number of tuberculin-reacting animals was 48·8 per cent. In Holland, the number of tuberculosed carcases in Amsterdam was 8·12 per cent., in Rotterdam 7 per cent., and in Leyden 4·17 per cent. In Copenhagen, in 1895, the number of tuberculosed carcases was 29·66 per cent., in 1896, 25·31 per cent., and in 1897, 26·87 per cent. Of 245,000 cattle tested by tuberculin, 28·8 per cent. gave positive reactions. In Sweden, the positive reacters were between 42 per cent. and 47 per cent., while in Norway of native cattle only 6 to 7 per cent, and of Scottish imported cattle 18 per cent.

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[1] *Trans. Roy. Inst. Pub. Health*, 1901, p. 234.

[2] In this group is included the milk of over 100 cows in which the udder was found on veterinary inspection to be diseased. From 25 to 29 per cent. of the samples from these cows produced tuberculosis in guinea-pigs. M'Fadyen and Rowland found tubercle-bacilli in 22 per cent. of the samples which they examined.

The prophylactic measures proposed by Bang to stamp out the disease in cattle are these: (1) Recognition of all affected animals and their compulsory notification, followed by the examination of all animals which have been exposed to contagion; (2) Destruction of all animals so diseased as to be able to transmit the disease to other animals; and (3) Complete isolation of all animals slightly affected, and the slaughter of these as disease tends to develop. As showing the need for systematic periodic inspection of cows, he points out that of 31,000 animals between April 1896 and May 1898 which did not react to the tuberculin-test, 4524 or 14·6 per cent. did react the following year to the test.

Considerable impetus has recently been given to the repression and prevention of tuberculosis by international conferences and congresses which are calculated to awaken the nations against the most fatal endemic scourge of modern times. Among the principal of these congresses was that held in London in July 1901. At that Congress, which has been rendered famous because of the unexpected and startling pronouncement in the address of Koch that human tuberculosis differs from bovine and cannot be transmitted to cattle, that human susceptibility to bovine tubercule is exceedingly slight, and that if such susceptibility does exist the infection of human beings is "but of very rare occurrence," several other celebrated Continental sanitarians played prominent parts, and, notably in the address of Brouardel of Paris, showed what steps were being taken in their respective countries towards the stamping out of human tubercular disease. From the institution, moreover, of a British Association for the Prevention of Tuberculosis, with branch Associations in the various important populous centres of the kingdom, some amelioration of this very prevalent and polymorphic disease may be expected. But this can only be achieved after many years of persistent, patient, and painstaking labour, not only on the part of the Association, but of Local Authorities, urban and rural, and of the population itself on the lines which have been considered in these pages. With respect to the statement of Koch already referred to, it would be unwise, in our view, that Local Authorities should cease their aggressive action against tuberculosed cattle, dead or alive, and milk from tubercular animals. The question of transmission or non-transmission of bovine tubercle to human beings cannot be allowed to depend upon the dictum of any one man, however eminent, and researches by private observers, in addition to the light thrown on the subject by the labours of the Royal Commission appointed for the purpose, may be expected to settle the question once and for all.

The Royal Commission on Tuberculosis (Human and Bovine), which was appointed after Koch's pronouncement, issued its Second Report in 1907. This Commission was appointed to inquire and report with respect to tuberculosis—

I. Whether the disease in animals is one and the same;

II. Whether animals and man can be reciprocally infected with it;

III. Under what conditions, if at all, the transmission of the disease from animals to man takes place, and what are the circumstances favourable or unfavourable to such transmission.

In arriving at an answer to the first question the Commission under-took experiments as follows :—(*a*) to investigate the effects produced in the bovine body by the introduction of the bacillus of human tuberculosis ; and (*b*) to investigate the effects in the bovine body of the introduction under similar conditions of the bacillus of bovine tuberculosis. The animals used for experiment were Jersey cattle, because of their remarkable freedom from tuberculosis. Jersey calves were experimented upon by tuberculous matter either in the form of (*a*) an emulsion of tuberculous lesions, or (*b*) cultures of the organism grown from these. The modes of introducing the virus into the animals was (1) feeding, (2) injection into the tissues subcutaneously, or intravenously or intramammarily. The site chosen for subcutaneous injection was, generally, the left side of the neck. The effects were as follow : At or near the seat of injection a swelling of variable size, and of variable rapidity of growth developed, which either remained hard and firm, or, especially when cultures were used in the injection, there was formed in its interior a cavity containing serous fluid. Soon after injection the nearest lymphatic gland—the prescapular—began to be enlarged, which increase in size developed with varying rapidity until a tumour of very large dimensions was formed. A similar enlargement of the prepectoral gland did also take place in some instances. About the twelfth day after injection, the temperature of the animal rose ; it became ill and lost flesh ; lung-troubles after appeared ; and within from 20 to 50 days the animal died, or was so ill that it had to be killed. Post-mortem examination revealed the local neck-lesion to be a mass of caseous tubercle which infiltrated adjoining skin and muscle, sometimes, indeed, forming an abscess. The prescapular gland, as well as the prepectoral, and, to a variable extent, also the thoracic and mediastinal glands, were found to be masses of caseous tubercle. Tubercles were to be found to some extent in all the lymphatic glands of the body. The lungs, spleen, liver, and kidneys were studded with tubercles, many of them caseous, and tubercles were also found on the pleura, omentum, peritoneum, and in the walls of intestine. This result may, therefore, be characterised as an acute generalised progressive tuberculosis which ends fatally within a few weeks.

But in other cases the effects of injection of the *B. tuberculosis bovis* were different. The local neck-lesion after enlarging merely to a limited degree gradually diminished in size ; the glands—prescapular and prepectoral—might enlarge at first, but later they diminished in size ; the animal showed, at first, a rise of temperature and some disturbance of health ; but the symptoms disappeared, the animal recovered, increased in weight, and became quite well. If the body of such an animal be examined after killing it, the local lesion will be found to be composed of tuberculous tissue largely calcareous, as will also be other tubercular lesions that may be found in the body. This condition may be fairly described as a retrogressive tuberculosis. Between these extremes, various intermediate stages were found in the experimental animals.

The Commissioners agreed that the results depended upon the dose of virus—number of organisms—injected. Of twenty different viruses tested on bovines, in eighteen, doses of 50 milligrams of culture always produced a fatal generalised progressive tuberculosis, but when in two instances, a dose of ·02 milligrams and ·01 milligram respectively was used, the result in each case was a limited retrogressive tuberculosis.

When intramammary injection was made, *i.e.* when the tuberculous emulsion or culture was introduced through the teat canals into two quarters of the udder, thus leaving the other two quarters for comparison—the injected quarters soon became affected. In some instances the disease remained in these quarters and did not extend into the other quarters, or into the body beyond the supramammary gland connected with the injected quarters. In such cases the disease after a while either retrogressed, or led to the death of the animal apparently due to absorption of toxic substances from the affected udder. But in other cases the disease spread into the uninjected quarters and over the body generally, causing death by general progressive tuberculosis.

Tubercular milk was obtained from the animals so treated and was used for feeding experiments on calves. In each of six cows so affected in the udder calves were allowed to suck for varying periods beginning the day after or a few days after the injection. In the case of one calf only was generalised tuberculosis produced. In the other five, which were killed after being kept alive from 74 to 363 days, tuberculosis was produced, but it was limited in distribution to the intestines and the mesenteric glands, and, in some cases, was also found to a limited degree in the liver or other internal organ. Fourteen calves, aged from three and a half weeks to two months, were hand-fed on tuberculous milk, six from one source and eight from another. None of these, when killed, showed more than tuberculosis limited to the intestine and the mesenteric or ileo-colic glands although fed for periods ranging from 36 to 127 days. In one case only was tubercle found in the pharyngeal glands. Guinea-pigs, rabbits, pigs, goats, dogs, cats, rats, mice, monkeys and anthropoid apes were all affected by tuberculosis either by feeding or inoculation with the organism of bovine tuberculosis. The foregoing results may be summarised thus :—the bacillus of bovine tuberculosis, introduced subcutaneously as emulsion or culture, may produce (*a*) fatal generalised progressive tuberculosis ; (*b*) limited retrogressive tuberculosis ; and (*c*) intermediate effects, the chief factor in the difference of result being the amount of dose or number of bacilli injected, there being more difficulty in producing like results by feeding ; and that the results point very strongly to the conclusion that the bacillus of bovine tuberculosis is " not only as effective but even more effective in causing tuberculosis in some of the above animals than in the bovine animal itself," as, for example, in the guinea-pig.

Effects produced on Bovine Animals by Human Tuberculosis.—The *materies morbi* employed in the following experiments on bovine animals consisted of tuberculous cervical glands removed by operation from the human subject, lesions of primary abdominal tuberculosis, tuberculous mesenteric glands, lungs, bronchial glands, kidney, testis, and joint or bone affections. When the tuberculous matter in the form of emulsion was injected subcutaneously into ten calves or heifers, generalised tuberculosis was produced in every case. In four instances it was of a fatal generalised progressive type, in other four it was generalised and progressive but not severe enough to be fatal, and in three, it was limited and retrogressive in type. When similar matter was introduced into the animal by intramammary injection, the result invariably was tuberculosis of the udder. When injected into rabbits, guinea-pigs, goats, monkeys, dog, chimpanzee, generalised tuberculosis was produced. When cultures of the organism amounting to 50 mgr. from cultures twenty-one days old were injected subcutaneously, the result in no case was more than a limited retrogressive tuberculosis in the form of either (1) a circumscribed retrogressive local lesion, often softened in the interior; (2) a retrogressive tuberculosis of nearest lymphatic glands; or (3) a few small, scattered, retrogressive tubercles in various organs. In some cases, even using doses as large as 3000 mgr., no more severe results than those named were produced. Injection of cultures into rabbits, guinea-pigs, monkeys, and chimpanzee produced in the first-named animals but limited retrogressive tuberculosis, and in the three last-named, generalised progressive tuberculosis. The effect of feeding bovine animals with sputum of human tuberculosis was as follows:—In two heifers fed with a daily dose of sputum, one for 200, the other for 300 days, several mesenteric and a few hepatic glands were found to be tuberculous, caseous, and calcareous. In four calves similarly fed, one for 91, and the others for 120 days, the mesenteric or adjoining glands were found to be affected with retrogressive calcareous tuberculosis, and in some of these, the pharyngeal glands were also affected.

The Commission, looking at the foregoing results, declared that "beyond all doubt human tuberculosis cannot be distinguished from bovine tuberculosis," and that "the human body can be infected by bovine tuberculosis."

"There can be no doubt," concluded the Commission, "but that in a certain number of cases the tuberculosis occurring in the human subject, especially in children, is the direct result of the introduction into the human body of the bacillus of bovine tuberculosis; and there can also be no doubt that in the majority at least of these cases the bacillus is introduced through cow's milk. Cow's milk containing bovine tubercle-bacilli is clearly a cause of tuberculosis and of fatal tuberculosis in man. . . . Our results clearly point to the necessity of measures more stringent than those at present enforced being taken to prevent the sale or the consumption of such milk."

Considering the possibility of scarlet fever, enteric fever, and diphtheria, as well as tubercle, being transmitted by milk, an effective method of preventing infection is to boil the milk. The chief objection to boiled milk is its taste. This, however, becomes unnoticed if children are used to it from infancy. It may, besides, be minimised by the use of milk-sterilisers, in which the milk is rendered practically sterile by exposure to a temperature short of boiling-point for some minutes. The operation is easily carried out for infant-feeding by placing the milk in a bottle which, in turn, is put into a vessel containing water. By heating the latter until the temperature of the milk is raised to 160–170° F., and keeping the milk at that temperature for fifteen minutes and then rapidly cooling it, the milk is sterilised. By keeping the bottle stoppered while the contents cool, no organisms can enter from the atmosphere. Sterilisation, or Pasteurisation as it is sometimes called, is carried out on a large scale in Copenhagen, Berlin, and other continental cities, before the milk is sold. The Corporation of St Helens, Lancashire, has followed the example of the town of Fécamp in Normandy, in sterilising the milk used for infant-feeding, with a view to reducing infantile mortality. The temperature to which the milk is subjected in this instance is 102° C., and the time of exposure, three-quarters of an hour. Milk so treated, according to Drew Harris, does not possess a " boiled " taste, is perfectly sterilised, and will keep sweet for over a month in closed bottles.[1]

While the term " sterilisation " and " Pasteurisation " are indiscriminately used, it ought to be understood that they are not descriptive of one and the same process. Sterilisation of milk is a relative term. To render milk absolutely sterile, it must either be raised to such a high temperature and for such a period as would change its appearance and constitution, or it must be exposed to a lower temperature on successive occasions. Pasteurisation means the exposure of milk to a temperature of about 70° C. for ten to fifteen minutes, and then to rapid cooling to prevent the development of spores before it is used. The latter process does not render the milk absolutely sterile, but only relatively so. Weber,[2] from the results of his investigation of the effects of sterilisation of milk, affirms that the following changes take place in milk when that fluid is subjected to the sterilising process for longer than 15–20 minutes, viz.: (*a*) an alteration of the albumens; (*b*) aggregation of fat globules; (*c*) loss of CO_2; (*d*) caramolisation of the lactose; (*e*) decomposition of the lecithins; all of which changes impair the nutritive value.

In order to lessen pulmonary tuberculosis, the system of notification as carried out for other zymotic diseases has by some been strongly advocated. Voluntary notification already exists in several populous centres. Compulsory notification is established by law in Norway, Spain, and other countries. There is much to be said in its favour, and there are equally strong objections to its practical use. It is, however, the only logical issue, whatever views may be entertained as to its expediency. The desiccated expectoration of phthisical persons being, doubtless, an important factor in the genesis of the disease, attempts have been made in various countries to compel the cessation of indiscriminate expectoration in public places, and the disinfection of tuberculous sputum.

The experiments of Cornet of Berlin with respect to the dust of rooms and hospital-wards occupied by phthisical patients, and of Prausnitz and Petri with respect to the dust of railway-carriages, amply prove the presence of *B. tuberculosis* and other micro-organisms therein. Of ninety-one animals inoculated by Petri with the sputum found in railway-carriages, twenty-eight succumbed to diseases produced by the inoculated material. In the bodies were found different pathogenic organisms, such as *S. pyogenes aureus* and *albus*, *Streptococcus pyogenes*, Eberth's bacillus of pseudo-tubercle, and the bacillus of mouse septicæmia. Of the other sixty-three animals, which were killed at the end of six weeks after inoculation, three were suffering from tuberculosis.

But many obvious difficulties emerge in the accomplishment of the above desiderata. In Germany, France, and America, and in certain of our own cities, public attention has been called to the serious danger from tubercular sputum, and instructions have been printed and distributed broadcast in order to educate the public. The chief points embodied in these leaflets are: (1) that the infective matter of the consumptive person is chiefly located in the sputum; (2) that it is only capable of doing harm when the sputum becomes dried, because then it is liable to become air-borne; (3) that, therefore, the sputum should be collected on pieces of paper, old cotton, or linen, and burned, and when phthisical persons walk abroad, that the sputum should be received into pocket spittoons, the contents of which may be washed into a drain, or better, should be consigned to the fire; (4) that when phthisis commences, the patient should be warned not to swallow the expectoration; (5) that the consumptive patient should sleep alone in a room occupied by himself only; and (6) in the event of death occurring from the disease, that the room and contents should be disinfected.

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[1] *B.M.J.*, vol. ii., 1900, p. 427.

[2] *Arbeit. kaiserliche Gesundheitsamte*, 1900.

The establishment of sanatoria for the open-air treatment of incipient cases of phthisis has been strongly advocated by reason of the fact that in the early stages of the disease it is curable. Pathological examination of bodies has demonstrated the frequent existence of cicatrices of healed cavities caused by the disease. Such establishments, situated at high altitudes in dry air, unmistakably produce improvement, and cure in suitable cases, but it must not be supposed that like good effects will follow in advanced cases, because in these mixed infection has probably occurred.

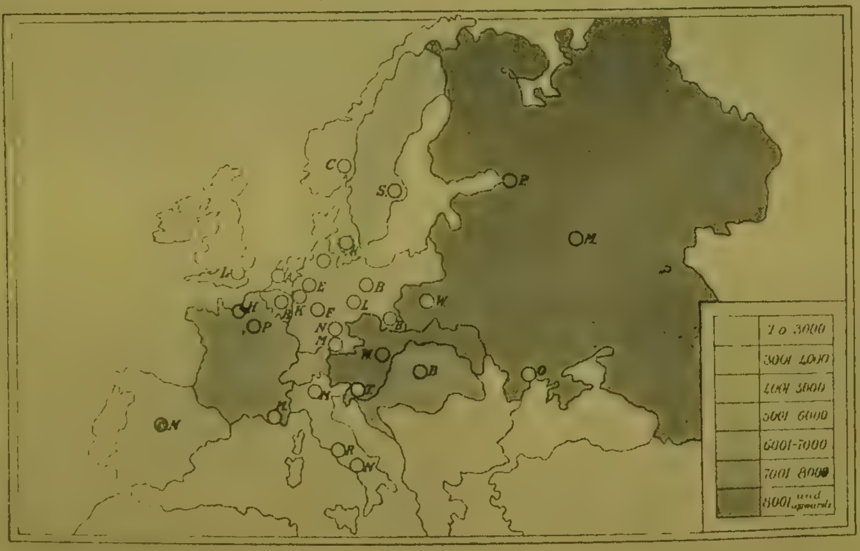

FIG. 118.—Map showing relative prevalence of Tuberculosis in certain European countries and in Asia. Capital letters in Figure signify the initial letters of the capital cities. The various shadings, when compared with the shaded key, indicate the number of deaths per million of population in the respective countries. It will be noted that no returns are given for Spain (except the city of Madrid), Turkey, Greece, Portugal, and the Danubian States. (*Vide* City of Edinburgh Report on Prevention of Consumption.)

That all such measures as the foregoing are necessary, is indicated by the fact that, of all the zymotic diseases, phthisis has shown least tendency to diminution from general sanitary measures. It is near the mark to say that one-seventh of the total annual deaths in the world are due to tubercular disease.

The Local Government Board of Scotland on 10th March, 1906, issued a circular letter to Local Authorities and medical officers of health on the subject of "Administrative Control of Pulmonary Phthisis." The results embraced in it were founded on the returns by medical officers of health to a schedule of inquiry issued by the Board in May of the previous year. With a view to assisting Local Authorities to develop and complete their administrative machinery for the full control of pulmonary phthisis, the Board in the letter directed attention to the following points—viz.

I. Pulmonary phthisis is an infectious disease within the meaning of the Public Health (Scotland) Act, 1897. Accordingly, those sections of that Act which are applicable to other infectious diseases are equally applicable to pulmonary phthisis, hence the obligation to deal with and control infectious disease on the part of Local Authorities extends also to pulmonary phthisis.

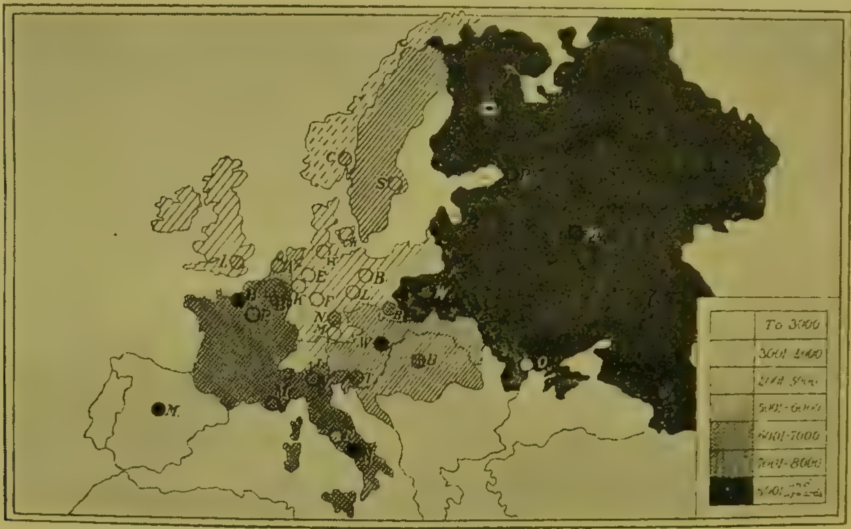

FIG. 119.—This Map graphically represents the relative prevalence and incidence of Inflammatory Diseases of the Lungs, excluding Phthisis, in different countries of the Old World, estimated as deaths per million of population. (*Vide* City of Edinburgh Report on Tuberculosis, 1900.)

II. *Powers as to Disinfection.*—Sections 46, 47, 48, and all other provisions of that statute with regard to disinfection of infectious disease shall be applicable to pulmonary phthisis, and it is the duty of the Local Authority to enforce these provisions whenever necessary. Sections 51 and 53 enable them to deal with rooms and houses in which cases of phthisis have developed, and owing to the dissemination of the disease by desiccated sputum, they should arrange with those in charge of places of common resort, such as schools, churches, theatres, railway-stations, and the like, and of public conveyances, to have the same periodically disinfected by the officers of the Local Authority. The provisions of section 50, which forbid the exposure of infected matter or articles, and of section 56, which prohibits infected persons exposing themselves in public places without proper precautions against spreading the disease, should be enforced; and the Local Authority should also use the powers contained in section 58, and see that no person suffering from pulmonary phthisis should engage in any occupation connected with food, or carry on any trade or business in such a manner as was likely to spread the disease.

III. *Powers as to Isolation and Treatment.*—The provisions of the Public Health Act contained in section 54, as to removal of cases of infectious disease to hospital, and in section 66, as to provision of hospitals and houses of reception, are available for pulmonary phthisis as for any other infectious disease. Local Authorities are advised either to utilise existing sanatoria or to combine with other Authorities in establishing a properly-equipped sanatorium for patients belonging to their districts, rather than each Authority to attempt to provide one for itself. The Board also drew attention to the different classes of those suffering from pulmonary phthisis, viz. (*a*) those in whom the disease was incipient, (*b*) those in whom it was well-established, and (*c*) those in whom it was advanced; and to the different grades of danger to which these severally exposed others. In addition, it was indicated that different kinds of hospitals, etc., were needed for that reason—viz. (*a*) curative hospitals or sanatoria for incipient cases; (*b*) all-day hospitals for open-air cure; (*c*) all-night hospitals for those who are engaged in occupation by day and whose homes are unsuitable for living in at night; (*d*) convalescent homes or work-colonies; (*e*) hospital-wards for educative treatment and control; (*f*) hospital-wards for isolation of advanced cases; (*g*) dispensaries.

IV. *Notification.*—Local Authorities might now add pulmonary phthisis to the list of diseases notifiable under the Infectious Disease (Notification) Act, 1889, with the approval of the Board, and the Board would be prepared to give favourable consideration to any application for such approval, provided they were satisfied that the Local Authority were in a position and ready to deal effectively with the cases notified to them. "Notification," added the Board, "of itself has no administrative value, and unless it is to be followed by effective measures for curative treatment of the patients and for the prevention of the spread of infection, the Board will not feel justified in approving of the compulsory notification of cases of the disease."

V. The Board suggested the appointment by a Local Authority of a committee to organise and administer the measures to be taken against the disease, which should be called the Phthisis Committee; and it further reminded Local Authorities that, while direct means for repressing the disease were of great importance, of, perhaps, no less importance was the attention which ought to be given to indirect means, such as unremitting and systematic removal of nuisances, prevention of overcrowding, enforcement of good ventilation, reconstruction of insanitary dwellings, improvement of insanitary areas, improvement of sub-soil and domestic drainage, stringent examination of meat and milk supplies, of cowsheds and dairies, cleansing of streets, removal and proper disposal of refuse, and many like conditions.

Since the issue of this circular several Local Authorities have taken the necessary steps to make pulmonary phthisis compulsorily notifiable. The compulsory notification of this disease took effect in Glasgow on 1st January 1910, in Edinburgh in 1908, in Leith in 1909, and by section 45 of the Sheffield Corporation Act, 1903, it also became compulsory in that town.

Naismith has collated the mortality-returns for Scotland from tubercular diseases from 1855 to 1891, in the following Table[1] :—

TABLE XLI

Years	Number of Deaths
1855–1864	105,275
1865–1874	102,193
1875–1884	118,286
1885–1894	100,671

In 40 years therefore, in Scotland alone, nearly half a million deaths have been caused by the tubercle bacillus. During the last forty years, however, the death-rate from pulmonary phthisis in England has fallen by two-thirds, and in Scotland by more than a half, compared with former rates.

TABLE XLII

Showing Number of Deaths and Death-rates in Scotland from Pulmonary Phthisis, 1899–1904

Year	Number of Deaths	Death-rate per 1000 of Population
1899	6,814	1·551
1900	6,804	1·526
1901	6,400	1·431
1902	6,068	1·338
1903	6,092	1·326
1904	6,151	1·329

TABLE XLIII

Showing Number of Deaths and Death-rates in the Fifteen Largest Towns in Scotland from Pulmonary Phthisis, 1899–1904

Year	Number of Deaths	Death-rate per 1000 of Population
1899	3,409	1·801
1900	3,437	1·784
1901	3,275	1·674
1902	3,106	1·551
1903	3,092	1·520
1904	3,035	1·481

If the deaths for 1904 for the whole of Scotland be divided in respect of their rural and urban incidence, they show as follows :—

	Deaths	Death-rate per 1000
Landward Districts	1,735	1·108
Burghs	4,416	1·441
Total,	6,151	1·329

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[1] *Trans. San. Ass. of Scot.*, 1896–97, p. 52.

The mean phthisis death-rate for the whole of Scotland in 1899–1904 was 1·415 per 1000 of population, but in the counties of Dumfries, Kirkcudbright and Sutherland it was 1·7 per 1000—the highest of all,—while in the counties of Linlithgow and Nairn it was 0·9 per 1000—the lowest of all.

It is likely, indeed, that such measures as the foregoing, in addition to increased numbers of open spaces in our cities, closer attention to ventilation of occupied rooms and workshops, greater insistence on smoke-consumption, street-cleansing, and scavenging generally, rigorous periodic examination of milch cows, and systematic meat-inspection, will produce a lowered mortality from tubercular diseases ; but so long as crowded, imperfectly lighted, badly-ventilated houses exist, the disease will more or less prevail.

Pulmonary tubercle is confined to no country and to no hemisphere. (*Vide* Figs. 116, 118.) It has been held by some that its prevalence is in some way due to the measure of amount of moisture in the soil, but it is doubtful if this can be stated as a general principle. The potent factors in its production are not so much existent in the soil or in altitude, as in the intimate home-life of the people and the conditions of their environment, and to some extent also of their employment. Consanguinity is an important factor in its spread in respect that it produces a type of constitution ill-fitted to resist the invasion of the bacillus. Davies[1] has established this with reference to the Manx population. Over a period of fifteen years the average annual death-rate from phthisis in the Isle of Man was 25·7 per 10,000 living, or about double the rate for England and Wales.

National and ritual habits seem, however, also to play some part in the predisposition to the disease. It has frequently been observed that the Jewish people seem to be less liable than other peoples to phthisis. So far this has been put to the test of statistics. In 1900, the Jewish population in London numbered approximately 73,000, with a phthisis death-rate of 12·3 per 10,000, and in 1906 had increased to 84,000, with a rate of 13·3 per 10,000. The following Table gives some further comparative data :—

Table XLIV

London

Proportion of Deaths from Phthisis to 100 deaths from all causes			Annual Death-rate from Phthisis per 1000 Persons Living	
General Population	1891–1900	9·3	1891—1890	17·9
	1906	9·2		
Jews	1897–1901	9·2	1900	12·3
	1901–1906	5·6	1906	13·3

These better results have been attributed to the higher family-instinct among the Jewish race, which leads to better care of the young in feeding, clothing, and cleanliness. Owing to the scrupulous care exercised with respect to the flesh meat which they may eat, the Jews cannot be so exposed to the risks of infection from tubercular flesh of any animal, and least of all from pork, which they do not eat. It has been remarked by those competent to judge, that in the East end of London the standard of living of poor Jews with respect to food, clothing, and cleanliness is higher than that of Gentiles of the same class.

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[1] *B.M.J.*, vol. ii., 1900, p. 904.

Tuberculins.—Koch's original tuberculin, which was brought forward in 1890, was a clear brownish fluid, obtained by filtering through a porcelain filter a glycerine-broth culture of the tubercle-bacillus and evaporating the filtrate on a water-bath to one-tenth its original volume. This may be called " crude " tuberculin. When injected in small doses into the body of a person or animal suffering from tuberculosis, a marked rise of temperature ensued, and an inflammatory reaction was established around any tuberculous foci in the body. If the latter was very marked, necrotic changes took place in the periphery of the foci and the necrosed tissue was thrown off. This form of tuberculin ceased to be used because of the amount of constitutional disturbance it produced and, also, because of the exceedingly small doses to be administered.

In 1897, however, Koch adopted a new method of preparing tuberculin.[1] He took highly virulent young cultures of the bacillus, thoroughly dried them and ground them carefully in an agate mortar so as to liberate the specific material and render it more soluble in water. Distilled water having been added, the mixture was centrifugalised, which separated the fluid into an upper layer, opalescent in appearance and bacilli-free, and a lower layer of deposited solid material. This deposit was again dried, and treated *de novo* as before. In like manner the clear fluid layer was also centrifugalised until it became quite clear. The upper fluid layer obtained after the first centrifugalisation Koch called TO, and the similar layer after subsequent treatment and centrifugalisation of the solid layer he called TR. This TR fluid yielded a precipitate when treated with glycerine, but not the TO fluid, therefore the TO fluid is looked upon as containing substances soluble in glycerine, and the TR fluid as containing substances insoluble in glycerine. The TO fluid is, therefore, more nearly akin to the old " crude " tuberculin, while the TR fluid is believed to be not only free from the dangerous properties of the " crude " preparation, but to contain valuable extracts of the organism ; in other words, Koch was of opinion that all the immunising substances of *B. tuberculosis* were contained in the TR fluid, and that a person immunised with it will not react with relatively large doses of the TO fluid. The effect of Koch's TR fluid on human subjects was discussed by several users of it at the Paris Tuberculosis Congress of 1898, and opinions differed as to its value.

Klebs, in 1891, after having considered the properties of the " crude " tuberculin of Koch, formed the view that the dangerous element which it contained was of an alkaloidal nature. He thereupon produced a substance, said to be freed of that element, which he called " tuberculocidin." This he held to be very destructive to the tubercle bacillus, to be free from injurious effects, and to be of therapeutic value.

Maksutow in 1897 objected to tuberculin on the ground that it was prepared from organisms grown on artificial media, and not on its natural soil, and that it was most likely that the objectionable property it possessed was due to the fact. He proposed to substitute in its place an extract from the tuberculous tissues of guinea-pigs, from which was prepared a bacilli-free substance to which he gave the name of "tuberculosetoxin." For this substance he claimed that it was capable of immunising animals in the course of a few months. In 1898, Landmann discovered what he called "tuberculol," which consists of an extract from the tubercle-bacillus with normal saline, distilled water, and glycerine at progressively rising temperatures, the first extract being made at 40° C., and the last at 100° C. The final product was composed of the mixture of these different extracts.

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[1] *Deut. med. Woch.*, No. 14, 1897 ; *ibid.*, No. 48, 1901.

The treatment of phthisis has also been approached from the anti-serum side, Maragliano having prepared an anti-tubercle serum from the horse. The animal is gradually immunised by inoculation with a mixture of tuberculous toxalbumins of watery tuberculin in gradually increased doses. Its therapeutic value has varied in the hands of different users. This line of treatment was keenly criticised by Landowzy, who predicted failure on the ground that to obtain an anti-tuberculous serum of real therapeutic value, it was necessary to be able to immunise an animal, and that, so far as experience had shown, was practically impossible.

Hirschfelder in 1898 brought forward another form of tuberculin, called by him oxy-tuberculin, made by cultivating *B. tuberculosis* in veal-broth with 4 per cent. of glycerine, 1 per cent. of peptone, and 0·5 per cent. of sodium chloride, to which $\frac{N}{10}$ sodium carbonate is added in the proportion of 3 c.c. per litre. The virulent cultures thereby produced are sterilised by heat and filtered, and tuberculin is obtained. This tuberculin is then oxidised by heating at 100° C. for 120 hours, adding to it every twelve hours during the heating process 100 c.c. of oxygenated water of such a strength that one volume of the solution is capable of liberating 10 volumes of oxygen. Finally, the resulting product is slightly alkalinised with soda solution, and is then allowed to stand for some time. It is thereafter preserved for use in sealed tubes after sterilisation by heat, or by adding to it 2 per cent. of boric acid or 3 per cent. of glycerine. It is administered by hypodermic injection in a dose of 5 c.c. for the first week, then every three days, rising gradually to 20 c.c. doses or more. It does not produce a rise of temperature. Denys in 1902 prepared a tuberculin by growing the bacillus in glycerine-broth, filtering and using the filtrate, no heat being employed in any part of the process.

Tuberculin Test in Bovine Animals.—The usual dose of tuberculin for a cow or heifer varies from 35 to 45 milligrams according to size of animal. The part to be injected is carefully prepared and sterilised by a solution of 1 : 500 corrosive sublimate. The part usually chosen for injection is behind the shoulder. The test should only be used when the animal is in a normal state. The temperature in the rectum of a healthy cow varies between 100·5° F. and 102·5° F. The temperature ought to be taken morning and evening for three days prior to use of test. After injection of the tuberculin, the temperature should be taken 9, 12, 15, 18, and if possible, 22 hours thereafter. In a reacting animal, a rise of temperature takes place usually between the twelfth and fifteenth hour after injection, but sometimes as early as the ninth, and occasionally as late as the eighteenth hour. The rise to be characteristic ought to be 2·5° over the usual temperature of the animal, and it may amount to 5° or 6°. A slight rise of one degree or one and a half degrees should not be counted as a reaction, but any rise over 1·5° and below 2·5° should create suspicion.

CHAPTER XI

CHARACTERISTICS OF INFECTIVE SUBSTANCES OF ZYMOTIC DISEASES

As has already been indicated, the infective agency in zymotic diseases is the organism or its spores. Zymotic diseases differ as to their degree of infectivity. Each disease has what may be termed its striking distance, that is, the area around the infected person within which the infective material will take effect upon a susceptible person. Some diseases have long, others short, and others intermediate striking distances. Smallpox is a typical example of the first. This has been fully proved with respect to smallpox hospitals and neighbouring populations. For this reason, the English Local Government Board has advised that a Local Authority should not contemplate the erection of a smallpox hospital on any site where, within a quarter of a mile of it as a centre, there is a hospital or other like establishment or a population of 150 to 200 persons, or within half a mile of it a population of 500 to 600 persons. Typhus-fever affords a good example of the second. Whatever the nature of the infective agency, it appears to be rapidly destroyed or neutralised by abundance of air, for the infective zone is confined to the immediate vicinity of the affected person. The factor which seems largely to determine the area of infectivity in all zymotic diseases is the mode or channel by which the infective material is shed from the body. In many diseases, as erysipelas, scarlet fever, measles, and some others, it is thrown off not only in the bodily secretions, but also in the exfoliated scurf-skin, and thus it may be carried for considerable distances by the air or upon objects. In diphtheria it does not spread far from the body of the patient, being discharged mainly in the moist mucous throat-secretions. Too much has been made of the absence of the specific micro-organisms from the expired air of those suffering from zymotic diseases. The experiments of Koeniger and others amply demonstrate that the mere act of speaking discharges micro-organisms into the surroundings of the patient, as also the acts of coughing and sneezing. Therefore, in those zymotic diseases in which the organism has its natural habitat in the air-passages or lungs, it must be held that organisms are discharged by such acts as those named to render infective the air around the patient. In enteric fever and cholera, the infective matter is mainly thrown off in the intestinal discharges, hence so long as these are in a moist condition the infective matter is little likely to become air-borne; so soon, however, as the discharges become dry, air-borne infection becomes possible. It is for this reason that experience has demonstrated the relatively non-contagious character of these diseases.

All infective diseases pass through three stages—viz. *Incubation,* *Invasion, Infectivity.* These are arbitrary terms, however, and by no means indicate sequential conditions, since in certain diseases infectivity is contemporaneous with incubation and invasion. The duration of these periods differs in different diseases. Cholera has probably the shortest, and leprosy and rabies, the longest incubation-periods. Infectivity may be said to be existent in any case from the time the specific organism multiplies in the body until it ceases to exist. While, for example, in diphtheria a patient may have apparently recovered from an attack, the bacillus may be found for varyingly long periods thereafter in the nasal or throat secretions, and in enteric fever, in the urine and especially in the fæces long after the establishment of apparent recovery. Incubation may be defined as that period which comes between the growth of the specific organism in the body and the production of fever, the latter being the indication of its multiplication and toxic effect. It may be divided into two stages—viz. the *latent* stage, during which the existence of the organism in the body is not detectable by clinical symptoms ; and the *invasive* stage, during which clinical symptoms indicate bodily attack by the organism. The former has to do with the growth of the organism itself, the latter, with the effects of the growth of the organism upon the body. Incubation-periods vary in duration in different diseases.

TABLE XLV

Short Incubation-Periods (1 *to* 6 *days*)

Anthrax (in man)	1–1½ days
Cholera	1–3 ,,
Diphtheria	2–5 ,,
Erysipelas	1–4 ,,
Glanders (in man)	1–4 ,,
Influenza	1–6 ,,
Foot-and-mouth disease	3–5 ,,
Puerperal fever	3–5 ,,
Scarlet fever	2–4 ,,
Relapsing fever	about 5 ,,
Plague	3–6 ,,

Long Incubation-Periods (7 *to* 21 *days*)

Whooping-cough	7–14 days
Typhus-fever	7–14 ,,
Smallpox	10–15 ,,
Chicken-pox	10–15 ,,
Rabies (in animals)	6–24 ,,
,, (in man)	6 weeks to 2 years
Enteric fever	12–20 days
Measles	8–12 ,,
Rötheln	10–14 ,,
Mumps	14–21 ,,
Yellow fever	2–10 ,,

Variable Incubation-Periods

Malaria	6–20 days
Tuberculosis	very variable—usually long
Tetanus	,, ,, ; within 10 days

Invasion is the period between the intervention of the febrile symptoms and the appearance of the rash—where a skin-eruption is a usual phenomenon. In scarlet fever, it is from one to two days; in smallpox and typhus-fever, from two to three days; and in measles, from three to five days.

Infectivity is the period during which the infected person discharges from his body infective material. Its duration is limited to some extent by the intensity of the attack and the time which elapses before complete restoration to health. It only ceases when infective material ceases to exist in or to be discharged from the body. While a period of forty days may be held to cover the period in the majority of zymotic diseases, it must be held subject to modification. In view, for example, of the liability of "return" cases of scarlet fever where this period of isolation has been observed, the period of isolation or infectivity has been extended to eight weeks.

The infective period may be reckoned to last in the following diseases as follows:—

In cholera,—during the whole period of discharges, and for a week thereafter;

In smallpox and chicken-pox,—during the whole illness till after the last particle of the last crust has fallen from the body, and for ten days thereafter;

In scarlet fever,—during the whole illness until all exfoliated epidermis has been shed—eight weeks; or longer, if ear or throat sequelæ exist;

In measles and Rötheln,—during incubation-period, through febrile and eruptive stages, until all epidermis has been shed—twenty-one to twenty-eight days;

In whooping-cough,—during the whole period of attack, even before "whooping" occurs—six to eight weeks;

In mumps,—during whole illness, till ten days after parotitis has disappeared—not less than twenty-eight days;

In enteric fever,—during whole illness, until complete restoration to health;

In diphtheria,—during whole illness, till ten days after bacillus has disappeared from throat and nasal secretions—four to six weeks;

In erysipelas,—from beginning of inflammation of skin till ten days after peeling of skin has ceased—three to four weeks;

In plague,—during whole illness, until complete restoration to health—a variable period.

Exposure to infection implies the possibility of attack, and consequently, the question—How soon after such exposure may a child who has not previously had the disease be permitted to return to school?—is of considerable importance with reference to prevention. The English Medical Officers of Schools Association has established a code of regulations bearing on this question, the substance of which is as follows:—After thorough disinfection of person and clothing, the child may be permitted to return to school in the case of diphtheria, after 12 days; in measles, after 16; in German measles, 16; in smallpox and chicken-pox, 18; in scarlet fever, 14; in whooping-cough, 21; and in mumps, 24 days, after exposure to infection.

Modes of Spread of Infective Diseases.—The liability to attack by zymotic diseases is determined by exposure to the area of infection, either from an infective person or from infective material, and by predisposition, susceptibility, or vulnerability. The power of a zymotic disease to spread depends upon the character of the infective material and its capacity to live outside of the living body: for example, while tetanus is a microbic disease—the *B. tetani* being anaerobic—the disease cannot be conveyed from person to person by the air. Again, those infective materials which quickly succumb to fresh air and sunlight are limited as to area of infectivity, while on the other hand those which are more resistant, and are capable of sustaining an existence in media outside of the body, as in soil, food, water, sewage, etc., have therefore a larger field of infectivity. The modes by which infection may be transmitted are as follow: (1) by direct contact with the infective person; (2) by contact with anything which has been in contact with an infective person; (3) by intercommunication between animals and man; (4) transportation by insects, as the common house-fly, mosquitos, gnats, ants, fleas, etc.; (5) by water or food; and (6) by the air. The Public Health Acts make it penal for an infective person to expose himself or herself in a public place or vehicle, and for articles of infective clothing to be pawned or sold. It is likewise penal to let rooms which have been occupied by a person suffering from infective disease unless and until the rooms have been disinfected. The room occupied by the infective sick is deemed infective until it has been disinfected, and the same is true of a vehicle which has been hired for the conveyance of the infective sick, and of the contents of the room or vehicle.

The agency of insects in the transmission of certain diseases of this class is now well established, particularly of insects which seek their food in excrementitious matter and those which sting and suck the blood of the person. To the agency of the common fly must be largely attributed the widespread epidemic of enteric fever in South Africa during the currency of the war in 1900–1902, and to a more limited extent perhaps, the greater prevalence of that disease in privy-midden towns; indeed, flies fed on food containing cholera-bacilli pass these uninjured in their excreta. The common flea is deemed by many to be a factor in the spread of plague, and *B. pestis* has been found in their bodies; and mosquitos—the *Anopheles maculipennis*, *Culex pipiens*, and one or two others—have been proved to be important hosts of one form or another of the malarial parasite. Many other disease-bearing insects might be mentioned, as the tsetse-fly[1] in the production of the disease of that name among cattle, and the *Boöphilus bovis* in Texas fever of cattle. Of the water-borne zymotic diseases, cholera, dysentery, and enteric fever are probably the chief. These have been already discussed. Of foods, milk is probably the most liable to convey infective matter, as it is one of the best natural absorbents of infective or septic matter, and moreover offers an excellent nutrient medium for the growth of organisms. Milk-borne epidemics of enteric fever, diphtheria, and scarlet fever are far from uncommon. Unused milk which has been exposed in a sick-room ought to be treated as slops, and should not be partaken of by healthy persons. In prevailing epidemics of these diseases, the safest plan is to boil the milk for some minutes, in order to destroy all contained microbes and spores. Air-borne infection is probably the chief source of most of the zymotic diseases. Bacteriological examination of the air, street-dust, and soil of populous places indicates the enormous number of organisms contained therein, and, further, that the air is richer in organisms the drier the weather.

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[1] For information regarding the connection between this insect and sleeping sickness or *trypanosomiasis* in man in South Africa, see "Report on the Measures for the Suppression of Sleeping Sickness in Uganda," by Sir H. Hesketh Bell, 1909. Colonial Reports (Cd. 4990).

The proximate modes by which infective material enters the body are these: (1) *inhalation;* (2) *ingestion;* (3) *inoculation;* (4) *absorption.* In certain zymotic diseases the type of attack differs as is the chief organ attacked; in plague, for example, in certain cases the type is pneumonic, in others bubonic, and in others septicæmic. So that while infective diseases have elective seats of action, in certain of them there may be more than one elect seat.

The means by which the spread of infective diseases is prevented or minimised, are the following—viz. (1) *Prophylaxis;* (2) *Notification;* (3) *Isolation and Quarantine;* (4) *Disinfection.*

Prophylaxis is operative especially during the interval of an impending outbreak of zymotic disease and its actual appearance in a population. Prophylactic measures include: (1) general instructions to the people as to means, personal and domestic, best calculated to ward off the disease; (2) special attention to the working efficiency of sanitary measures, and the institution of protective measures, as for example, vaccination in smallpox; and (3) the establishment of a cordon between non-infected and infected inland countries or districts, or non-infected and infected ports in seaboard countries.

The other modes come into effective operation immediately the first case of the disease appears, and they aid in checking or limiting the further extension of the outbreak.

Notification of infectious diseases supplies a powerful instrument to Sanitary Authorities, first in enabling them to locate the area of the disease, to track its origin, to watch the lines of its extension, and to gauge its progress by the knowledge which is obtained of the number of persons attacked; and second, to concert suitable measures of isolation and disinfection to prevent its extension. The Public Health (Scotland) Act, 1897, section 47 (4), gives power to the Sanitary Authorities to remove if necessary all the inhabitants of houses within an infected area to places provided by the Authority, so that thorough measures of disinfection may be overtaken. The Infectious Diseases (Notification) Act of 1889, although at first a permissive or adoptive Act, was largely adopted by Sanitary Authorities throughout the country. It is still a permissive or adoptive Act for Ireland, but has been made compulsory for Scotland by virtue of section 44 of the Public Health (Scotland) Act, 1897, and for England and Wales by the Infectious Diseases Notification (Extension) Act, 1899. When the Act is adopted in any urban or rural district, the duty of notifying the existence of any one of the diseases named in the schedule of the Act falls upon: (1) the parent or guardian of the sick person, and (2) upon the medical attendant. The scheduled diseases are: Smallpox, cholera, diphtheria, membranous croup, erysipelas, scarlet fever, typhus-fever, enteric fever, relapsing fever, continued fever, and puerperal fever. It is competent for any Local Authority to add to the list of diseases above named, after due notice, conform to the terms of the Act, has been publicly given. Forms of certificate are supplied by the Authority to every medical practitioner, for each of which, duly filled, a fee of 2s. 6d. is payable for a private patient, and of 1s. for patients in public institutions or in public practice. Failure to notify is attended by a fine not exceeding 40s. It ought to be observed that the Act does not confer powers upon Local Authorities to remove patients compulsorily, or to enter the houses of the sick. Such powers may, however, be obtained on a warrant from a magistrate, by virtue of the Public Health Acts. In order to derive the highest measure of benefit from this Act, it is necessary for Local Authorities to institute sufficient hospital-accommodation for those who cannot efficiently be isolated at home, and in addition, reception-houses or houses for "contacts," *i.e.* those who have been in contact with the sick, for the lodgment of such persons during the incubation-period of the disease and while their homes are undergoing cleansing and disinfection.

Isolation and quarantine are valuable means of checking the spread of disease, and, although they do not mean the same thing, subserve the same purpose. The former in practice means the separation of the infective sick from the healthy in such circumstances as will prevent, as far as can be, the spread of the disease, and for such periods of time as infectivity prevails. Quarantine means the separation from the healthy of persons who, although themselves not yet actively infected, may become infective, and of things which may be the passive carriers of infection from an infected area, for such space of time as will demonstrate whether or not the former will become actively infected, and as will enable disinfection to be employed in respect of the latter. The practice of quarantine, however, does not cover the period of time (forty days) involved in the literal meaning of the word. It is usually confined to sea-going traffic in seaboard countries, and to passengers and luggage at frontier towns in inland countries. By the Convention of Venice of 1897, which was intended to prevent the spread of plague, it is incumbent upon the Government of an infected country to institute measures to prevent the exportation from its infected area of merchandise capable of carrying the infection; non-compliance with this agreement enables the other countries to impose restrictions on persons or merchandise coming from any port of the infected country, notwithstanding the absence of plague from the port in question.

The object of the International Sanitary Convention of Venice of 1897 was international protection against plague in those countries the representatives of which took part in the Convention. The Convention binds each Government to notify to the other Governments "the existence of cases of plague, the places where they have occurred, the date of their appearance, the number of cases reported, and the number of deaths," and it made the stipulation that in these reports information should particularly be given respecting the measures devised and taken to check the propagation of the disease, and, in detail, the preventive measures adopted as regards medical inspection, isolation, disinfection, and the measures prescribed regarding the departure of ships from ports, and the export of susceptible articles. The L. G. Board of Scotland issued to Local Authorities on 4th October, 1900, a Circular drawing their attention to the duties devolving upon them in the light of the provisions of that Convention.[1]

The chief provisions of the Venice Convention are as follow :—

Section I.

1. The Government of an infected country must notify to the other Governments the existence of all cases of plague.

2. The notification shall state the existence of such cases, the places where they have occurred, the date when they appeared, the number of cases reported, and the number of deaths. Such notification shall be made to the diplomatic or consular agents in the capital of the infected country, or, where there is no such representative, directly to foreign Governments. The first notification shall be followed by weekly communications for the purpose of keeping the other Governments informed.

3. The reports relative to the outbreak and course of the disease must be as complete as possible, and shall, in particular, state the measures taken to check its spread, and the preventive measures adopted with regard to medical inspection, isolation, disinfection, and the measures laid down respecting departing ships and the export of articles susceptible of carrying infection.

4. The Government of each country must immediately publish the measures which it decides to adopt with regard to arrivals from an infected country or local area, and shall at once communicate the same to the agent of the infected country resident in the capital, or, in the absence of such agency, direct to the Government. The withdrawal or modification of these measures shall be communicated in the same manner.

Section II. Conditions under which a local area (that is, any portion of the territory of a country under a recognised administrative authority) is to be considered infected or healthy.

1. Any area in which a case of plague has been officially reported to exist will be considered to be infected.

2. Any such area will cease to be so considered when it is officially reported that no death from or fresh case of plague has occurred for ten days after recovery or death of the last case, provided that necessary disinfection has been carried out.

3. Preventive measures shall be put in force as regards the infected territory as soon as cases of plague are officially reported, and such measures shall be discontinued when it is officially declared that the area has again become healthy. *The occurrence of a few imported cases in a local area shall not be regarded as warranting resort to these measures, unless these cases give rise to others.*

Section III. Necessity of restricting to the infected local areas the preventive measures adopted.

In order that the preventive measures adopted be restricted to the infected area, the Governments must apply them to ships, persons, and things from infected areas only, provided that the Government of the infected country takes the necessary measures to prevent the export of susceptible articles derived from the infected area; no restrictive measures should be enforced against ships, persons, or things from an infected area, if they left it at least five days before the occurrence of the first case of plague.

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[1] Public Health (Scotland) Act, 1897. Instructions, Forms, etc., 1903, p. 136. Issued by the Local Government Board for Scotland.

Section IV. Susceptible goods and articles considered in relation to rules regarding the prohibition of import or of transit, and to rules regarding disinfection.

1. Import and Transit

1. The following is a list of susceptible articles and goods the importation of which may be prohibited :—

(*a*) Body-linen, clothes that have been worn, and bedding that has been used; soldiers' and sailors' kits being returned home after death of their owners;
(*b*) Rags, carried as merchandise in bales;
(*c*) Used sacks, carpets, and used embroidery;
(*d*) Raw hides, untanned and fresh skins;
(*e*) Fresh animal-refuse, claws, hoofs, horse-hair, hair of animals generally, raw silk and wool.
(*f*) Human hair.

2. The transit of such goods packed in such way that they cannot be handled on the way must not be forbidden. When such are transported in such a manner that they cannot have come into contact with contaminated objects during the journey, their transit through an infected local area must not bar their importation into the country to which they are consigned. The rules prohibiting import of susceptible goods and articles shall not be applied where it is proved to the authority of the country of consignation that they were dispatched at least five days before the occurrence of the first case of plague.

3. Merchandise must not be kept in quarantine on land frontiers. Absolute prohibition of importation or disinfection if imported are the only measures which must be taken.

2. Disinfection

Disinfection shall be compulsory in the case of soiled linen, wearing-apparel, clothes and articles, carried as *personal baggage* or household goods, if they come from an infected area and if the local Sanitary Authority deem them contaminated; and with regard to *merchandise,* only such merchandise and articles which the Sanitary Authority considers contaminated, or whose importation may be prohibited.

The manner by which, and the place where such disinfection shall be carried out shall rest with the Authority of the country to which articles are consigned, and the disinfection must be carried out so as to injure articles as little as possible, compensation to be made by the country carrying out the disinfection in cases of damage.

Letters and correspondence, printed matter, books, newspapers, business documents, etc. (not including parcels received through the post), shall be subject to no restrictions or disinfection.

Section V. Deals with measures to be taken on land frontiers, and with regard to railway traffic and travellers.

Governments reserve to themselves the right to take special measures with regard to certain classes of people, especially gipsies and vagabonds, and emigrants and persons travelling or crossing the frontier in bands.

Section VI. Deals particularly with frontier tracts.

Section VII. Deals with water-ways, rivers, canals, and lakes, which communicate between different countries.

Section VIII. Deals with ocean-traffic and the measures to be taken at ports.

1. Any ship with plague on board, or on board of which one or more cases have taken place within twelve days, will be considered *infected.*

2. Any ship which had a case of plague on board at time of departure but on which no fresh case has occurred for twelve days, will be considered as *suspicious.*

3. Any ship, even though from an infected port, which has had no death from plague nor case of plague on board, either before departure, during the voyage, or on arrival, will be considered as *healthy.*

4. *Infected* ships are subject to the following rules :—

(*a*) The sick shall be immediately disembarked and isolated.

(*b*) Other persons on board must also, if possible, be disembarked and kept under observation or surveillance for a period varying according to the sanitary condition of the ship and the date of the last case, but which must not exceed ten days.

(*c*) Soiled linen, personal belongings, and articles belonging to crew and passengers, which in the opinion of the port Sanitary Authority shall be considered as contaminated, shall be disinfected.

(*d*) Bilge-water shall be pumped out after disinfection, and good drinking-water shall be substituted for the water stored on board.

(*e*) All parts of the ship which have been inhabited by plague patients must be disinfected, but more extensive disinfection may be ordered by the port Sanitary Authority.

Suspected ships are to be subjected to :—

(*a*) medical inspection ; and

(*c*)
(*d*) } of above for infected ships.
(*e*)

Surveillance should be kept over the health of the crew and passengers for ten days from date of ship's arrival ; that is to say, crew, etc., shall at once receive free pratique, but on arriving at their destination they will be subject to medical inspection (*vide* Order as to Cholera, Yellow Fever, and Plague, p. 464).

Healthy ships shall at once be given free pratique, but the port Sanitary Authority may enforce those measures applicable to suspected ships, except that measure with regard to disinfection of the ship itself.

Special measures may be prescribed for crowded ships, especially emigrant ships, or any ship in an insanitary condition.

Any ship objecting to submit to obligations imposed by the port Authority shall be free to put back to sea.

Goods arriving by sea must be treated in the same way as goods arriving by land, as regards disinfection, prohibition of import, transit, and quarantine. Disembarkation of goods may be authorised after (*a*) isolation of ship, crew, and passengers, (*b*) pumping out bilge-water after disinfection, (*c*) substitution of good drinking-water for the water stored on board. Passengers desirous to land shall only be permitted so to do on giving an undertaking that they will submit to the measures prescribed by the port Authority.

Each country must provide at least one port on each of its seaboards with the organisation and equipment necessary to enable it to receive a ship, whatever its sanitary state.

The Cholera, Plague, and Yellow Fever Orders of the English and Scottish Local Government Boards also contribute towards the prevention of the introduction of these diseases into Great Britain. By virtue of the Public Health Act, 1875, section 130, the former issued regulations on this subject in the form of an Order, dated 9th November 1896, and in virtue of the provisions of Part IV. of the Public Health (Scotland) Act, 1897, the latter also issued regulations of date 3rd January 1898, the terms of both of which will be considered later (*vide* p. 464).

The Quarantine Law of 1893 of the United States makes it unlawful for any vessel from a foreign port to enter any port in the United States unless and until a certificate of a clean bill of health has been obtained from the consular or medical officer of the United States at that foreign port; no vessel shall enter a port, or discharge its cargo, or land its passengers, except upon a certificate of the officer of health at the quarantine-station; where an infected vessel arrives, it is remanded to the quarantine-station for the necessary disinfection and treatment of vessel, passengers, and cargo, and, thereafter, on a certificate from the health officer that the vessel is free from infectious disease, or danger of carrying the same, it shall be admitted into port; when cholera or other infectious diseases in a foreign country may cause serious danger to the United States by its or their introduction, power is given to the President to prohibit, in whole or in part, the introduction of persons and property from such countries or places, and for such period of time, as he may deem necessary.

Ships which come from an infected port are required to lie out at sea, or in the port roadway within a prescribed anchorage, until crew and passengers have been examined by the port Sanitary Authority, and until—if sickness has occurred during the voyage—the ship and cargo have been disinfected. If, on the other hand, a clean bill of health be presented, and the number of days which have elapsed between the date of sailing from the infected port and the date of arrival at the quarantine-station be in excess of the incubation-period of the disease the introduction of which is feared, all that remains to be done is disinfection of ship and cargo. If the number of days be less, and if a sick bill be presented, then the crew and passengers are not allowed on shore till the period of incubation is past, or, if in apparent health, until after the addresses of their destination have been obtained.

It has been found advisable in populous places to provide retaining or reception houses which are practically quarantine-stations or stations of observation, wherein to place persons occupying houses of one or two apartments in which infective disease has broken out, and where they may be retained at municipal expense, until it is definitely proved that they have not become subjects of the disease. Such houses form a valuable adjunct to sanitary equipment, since they deal with that population amongst which insanitary conditions most generally prevail, and which therefore demands most supervision.

Isolation is either effected in the home, or in special isolation-hospitals for the reception of the affected sick. The possibility of efficient isolation in the home depends (1) upon adequacy of room-space; (2) efficient separation of sick-room from the rest of the occupied rooms; (3) proper nursing by one whose sole duty is confined to the sick-room; and (4) suitable means of disinfection of clothing, etc., during the currency of the illness. Under ordinary circumstances, it is impossible to attain efficient isolation in houses of three apartments or fewer, and even in larger houses the problem is difficult. It is, then, a safer practice to send the patient to an isolation-hospital.

Disinfection means those operations which are carried out against the infective material to destroy it, whether it be from the body of the infected person, his clothing, bed-clothing, or in the room which he has occupied, and its contents. Efficient disinfection includes them all. From imperfect disinfection disease is disseminated, and disinfective measures more usually err on the side of inefficiency than of over-carefulness.

CHAPTER XII

DISINFECTION

Disinfection includes all those processes the object and effect of which are the destruction of infective matter, the nature of the process being regulated by the character of the material which encloses or carries the *materies morbi.* A disinfectant may be defined as an agent which destroys the power of infective matter to further produce disease. Unfortunately the term is used indiscriminately to cover a number of the most valuable as well as the most inept substances. This has doubtless arisen from the nebulous conceptions which formerly existed regarding the entity of infective matter. Often associated with disagreeable odours, infective matter was supposed to be rendered inert by the use of deodorants. Since the microbic constitution of infective matter became established, however, such views have had to be revised, and the disinfecting power of any substance or agent must now be gauged by the measure of its capability to destroy micro-organisms and their spores.

Disinfectants may be divided into: (1) *Physical Agents;* and (2) *Chemical Substances.*

The principal physical agents which are inimical to microbic life are: (*a*) *Light;* (*b*) *Heat;* (*c*) *Cold.* Light, especially direct sunlight, is very destructive of micro-organisms after variable periods of exposure. Experiments have abundantly proved that such exposure is rapidly lethal to the organisms of erysipelas, enteric fever, tubercle, and anthrax, and in the case of others, if they are not actually killed, that their vitality and virulency are at least minimised. Such facts as these indicate the need for good lighting of houses, the value of open spaces and of good building-regulations, and the prevention of smoke-production. An adjuvant to good light is abundance of air. Of air as a germicide it may be said, that when it is fresh and abundant, it so dilutes infective matter as to reduce the virulency of organisms, if not, indeed, to destroy the organisms. As has already been said, the area of infectivity of typhus and other diseases is limited by the free diffusion of air, and in the case of anaerobic organisms which are not facultative aerobes, it arrests their operation entirely. The combination of air and sunlight has an important effect in the destruction of micro-organisms in water and sewage. The effect of such combination is included in the purifying effects of sedimentation in water-supplies.

Heat is a valuable bactericide when applied either as dry air, moist air, water, or steam. It is best adapted for the disinfection of body-clothing, bed-clothing, and room-furnishings, as carpets, rugs, cushions, etc., which have been exposed in an infected room. For clothing which will not be injuriously affected, boiling in water for twenty minutes to half-an-hour will completely disinfect them. Such treatment is suitable for cotton and linen fabrics. For woollen fabrics, feathers, hair-mattresses, etc., however, the most suitable treatment is by heated moist air, or by steam. Dry heated air, even under pressure, has been found by different experimenters to be inefficient, unless at such temperatures as are bound to scorch certain of the materials subjected to it. In order to destroy organisms and spores a temperature between 212° and 220° F. is necessary, and it has been found impossible by dry heated air to obtain this temperature in the interior of a mattress even after long periods of exposure. Moreover, according to the experiments of Koch and others with dry heated air, an exposure of four hours to a temperature of 220° F. is necessary to destroy spores, whereas with steam at 212° F., exposure for five minutes will effect the purpose. Consensus of opinion, arrived at by direct experimentation, is now solely in favour of moist heat. In an efficient disinfector where moist steam is used, the following are essential points: (1) that the steam under pressure should permeate thoroughly the articles to be disinfected; (2) that the temperature of the steam should be between 221° and 270° F.; and (3) that the apparatus is so constructed that, alternately, hot dry air and moist steam within the foregoing range of temperature should be passed into the chamber containing the articles to be disinfected. The disinfector constructed on the Washington-Lyon principle by Messrs. Manlove, Alliott & Co. is one of the best, and a description of the mode of using it will suffice for this type of disinfector of which there are several kinds with insignificant differences, and many makers.

This disinfector, which is oval in shape and constructed of steel, consists of an outer and inner chamber, the former being called the "jacket," in respect that it envelops the latter. When the apparatus is working, it is filled with steam at a pressure of 20 lbs. per square inch and of a temperature of 260° F. In the inner chamber is a movable cradle or basket, made of galvanised iron wire, in which the articles to be disinfected are placed. By means of valves, communication may be established between the outer and inner chamber, both for filling the latter with steam and for emptying it partially of air. The disinfector, then, being in working order, the following is a description of the process of disinfection from beginning to end: The inner chamber door is opened, the cradle is pulled out, and the articles are placed in it. The cradle is then pushed back into the chamber, and the steam-tight doors are shut. Steam under the conditions above mentioned having been meanwhile filling the outer chamber, the air of the inner chamber is partially exhausted by the action of a steam nozzle, the effect being to produce a partial vacuum within the chamber. At this stage the communication between the two chambers is opened, steam rushes into the inner chamber under considerable pressure, and forces itself into the pores of the articles. This part of the process lasts for not less than twenty minutes, but the time may be extended if the nature of the articles makes it necessary. The communication between the chambers is now closed, the steam of the inner chamber is now blown out, a partial vacuum is once more established, and hot air takes the place of the steam. The hot air takes up any moisture which may have become condensed upon the articles, which are now taken out of the cradle, the process of disinfection being completed. In municipal disinfecting-establishments where large quantities of materials must be handled daily, it is essential that disinfected goods should not be mixed with the infective. This is overcome by dividing the inlet-side from the outlet-side of the disinfector by a partition-wall which extends the whole length of the apartment; thus the infective articles put into the apparatus on the inlet-side, after disinfection are taken out on the outlet-side, and commingling is thus prevented. To the same type of apparatus belongs the disinfector of Messrs Goddard, Massey & Warner, with this essential difference that the pressure—20 lbs. per square inch—in inner and outer chamber is identical, and the steam is not *superheated.* In the Continental disinfectors, built on the Geneste and Herscher lines, there is no outer chamber or jacket, the steam-pressure in the disinfecting chamber is about 10 lbs., and the steam is not superheated. The term *superheated* demands a word of explanation. The temperature at which steam is generated depends upon the pressure to which the heated fluid is subjected. At ordinary atmospheric pressure, steam is generated from water at 100° C., or 212° F. If the pressure is increased, the temperature of boiling-point, and, consequently, of steam-formation, is raised as is the degree of pressure; thus, if the pressure be two atmospheres, the temperature of steam formation is 249° F., if three atmospheres, 273° F. Steam generated at these temperatures is said to be saturated, that is, it cannot do work by expansion, and it undergoes condensation on cooling. When, however, this saturated steam is further heated, it is said to be superheated; that is, its temperature being higher than the condensing-point relative to its actual density and volume, it can do work on expansion and can be cooled to some extent without undergoing partial condensation; in other words, superheated steam comports itself like a perfect gas.

But other disinfectors have been constructed on different principles. In that of Van Overbeck de Meyer, the steam is generated in the outer chamber at ordinary pressure, and is passed into the inner chamber by an opening in the top. In this machine the temperature is 212° F. In the machine invented by Dr Thresh, Medical Officer of Health for Essex, the temperature of the steam is 225° F. The principle upon which it is constructed is that water containing a saline substance in solution boils at usual atmospheric pressure at a higher temperature than ordinary water. The water in this apparatus is charged with calcium chloride, and the machine is so arranged that the calcium salt once added may do work for a considerable time by water being added to it as required from an automatic feed cistern. The generated steam having a temperature of 212° F., is made to circulate in a pipe which passes through this boiling solution and is raised thus to 225° F. The machine possesses an inner and an outer chamber, the latter containing the saline solution, and into the former are placed the articles to be disinfected. When the temperature of the inner chamber reaches the above temperature, the steam at the like temperature is made to enter, and thus acts upon the articles. The time allowed for disinfection is the same as in other machines. When the disinfecting process is complete, the course of the current of steam is turned by means of a lever from the inner chamber into the flue of the machine, and thus the inner chamber is converted into a dry-air chamber, any moisture which condenses upon the articles is vaporised, and they come from the machine dried. It is claimed for this apparatus that it attains (1) uniformity of temperature ; (2) rapidity and efficiency of penetration ; (3) maximum temperature in the interior of the articles being disinfected ; (4) dryness of articles on removal. Further, it has the merits of simplicity, non-requirement of skilled labour, and of safety.

Cold.—The agency of cold cannot be looked upon as a germicide. It may inhibit for the time being the growth of organisms, but that is all that can be said of it. Organisms can withstand exposure to very low temperatures without apparent prejudice. The experiments of M'Fadyen [1] and Rowland [2] absolutely prove this. They exposed a variety of organisms, pathogenic and non-pathogenic, sealed in fine quills, to the action of liquid air—temperature –312° F.—for seven days, and at the end of that time they proved by culture-experiments that the vitality and cultural characteristics of the organisms were in no way impaired.

Chemical Disinfectants.—A large number of substances popularly called disinfectants are merely deodorants or antiseptics, and have no virtue as germicides ; and since in practical disinfection destruction of organisms and spores is the objective point to be aimed at, they are worse than useless. The potency of any germicidal agent used depends entirely upon its strength, and upon its applicability for this purpose to the medium in which the organisms are located. When the germicidal value of any substance is spoken of, it ought to be with reference to its strength in the fluid in which it is being used, and not to its strength in the solution which is added ; thus, if it be said that a certain disinfectant is destructive of organisms in a 2 or 5 per cent. solution, it is meant that the fluid containing the infected substance must contain 2 or 5 per cent. in its whole bulk, and not merely that a solution of that strength is to be added. To the class of germicides belong : (*a*) mercuric chloride ; (*b*) biniodide of mercury ; (*c*) chlorine in gaseous form, or as chlorinated lime ; (*d*) formaldehyde ; (*e*) chloride of zinc ; and in addition, when used in sufficient volume, for aerial disinfection : (*f*) sulphurous acid gas ; (*g*) iodine vapour ; and in the disinfection of liquid or pultaceous substances : (*h*) the sulphates of iron, copper, and zinc ; (*i*) cupralum ; (*j*) carbolic acid ; (*k*) preparations of cresol ; and (*l*) the mineral acids.

The following Table indicates the substances which act efficiently as germicides when used of the named strengths :—

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[1] *Proc. Roy. Soc.*, vol. lvi.
[2] *The Lancet*, 21st April 1900.

[TABLE

TABLE XLVI

Table of Efficient Strengths of Disinfectants as Germicides

Disinfecting Agent	Strength and Medium in which to be used
Mercuric Chloride	1 in 1000 of water (70 grains per gallon). Solution to be aided by addition of common salt, and coloured with laundry blue. This may be used for disinfection of body- and bed-linen, and liquid excreta. The proportions proposed by the English Local Government Board are: ½ oz. mercuric chloride, 1 oz. hydrochloric acid, 5 grains commercial aniline blue — in 3 gallons of water. A solution of 1 in 4000 is excellent for washing woodwork and floors.
Mercuric Iodide	1 in 1000 of water for infected linen and stools; 1 in 2000 for hands and liquid stools; 1 in 4000 for woodwork and floors. Solutions ought to be rendered odorous by thymol, eucalyptol, or wood-naphtha.
Chlorinated Lime, or Bleaching Powder	4 parts per 100 of water (6 oz. to 1 gallon of water) for solid and liquid excreta. When used for the former, to be permitted to soak for about one hour before vessel is emptied. One part per 100 is excellent for hand-washing after visitation to sick-room and handling of patient.
Carbolic Acid	5 per cent. solution in water (1 in 20). Official strength used in Berlin, 1 in 18. To destroy bacteria a 10 per cent. solution is needed; water, however, will not dissolve so much.
Copper Sulphate	5 per cent. solution in water. To be used for disinfecting stools. Contact not less than one hour.
Zinc Chloride (Burnett's Fluid)	1 in 10 of water; for stools, as above.
Sulphurous Acid Gas (compressed in cylinders at three atmospheres' pressure)	Exposure for twelve hours to 4 vols. per cent. in a moist medium. 1½ lbs. of sulphur per 1000 cubic feet of air-space only gives 1·75 per cent.
Chlorine Gas	·5 to 1 vol. per 100 vols. of air.
Hydrochloric Acid Vapour	·05 to ·1 vol. per 100 vols. of air.
Bromine	1 in 2000 of water for solid excreta. Objectionable to user by reason of irritancy of vapour given off.
Formaldehyde	Used as a spray with steam, half a pint of formalin per 1000 cubic feet. Used as a gas or vapour, one pint per 1000 cubic feet. The formalin of commerce is a 40 per cent. solution of formaldehyde in water. If stools are mixed with an equal volume of a 10 per cent. solution, disinfection is rapidly produced.

Bacterial Tests with different Chemical Disinfectants

Spores of B. anthracis.—The following substances were found by Koch to kill the spores of this organism within 24 hours: chlorine water, 2 per cent.; bromine water, 2 per cent.; iodine water, 2 per cent.; corrosive sublimate solution, 1 per cent.; potassium permanganate solution, 5 per cent.; carbolic acid, 5 per cent.; and the following substances in the strengths indicated failed to do so within that time, and, indeed, took several days to do so, or failed entirely viz.—chlorinated lime, 5 per cent.; zinc sulphate and chloride, copper sulphate, ferrous sulphate, borax and boracic acid in 5 per cent. solutions; sulphurous acid solution, 5 per cent.; and hydrochloric acid, 2 per cent. Moist heat at 100° C. for one hour's exposure will also kill spores.

B. typhosus.—A 1·5 per cent. solution of chlorinated lime will kill the typhoid bacillus in fæces, 1 in 500 will disinfect ordinary sewage in fifteen minutes, 1 in 50 will kill tubercle-bacilli very quickly, and 1 in 10 will kill anthrax-spores.

Formalin acts well on a variety of substances. A 30 per cent. solution will disinfect pus in half an hour, and a 5 per cent. solution, the *B. choleræ Asiaticæ* in pure culture in three minutes, the *B. anthracis* in fifteen to eighteen minutes, and the spores of anthrax in five minutes.

It is important that disinfection should be carried out as efficiently as possible in practice. When a patient is confined to a sick-room, disinfection must not only follow the vacation of the room, but it must be concurrent with the illness, since the discharges and fouled clothing must be disinfected. As a safe, working principle it should be held that everything which comes from the body of the patient, which has clothed his person or his bed, or which has been used by him during the illness, should be considered infective, and should accordingly be disinfected.

In Smallpox, all discharges are infective. Nasal and throat discharges should be received on rags and burned; stools, vomited matters, and urine, disinfected with one pint of 4 per cent. solution of chlorinated lime, or a like quantity of 1 to 1000 solution of corrosive sublimate. The virus being concentrated in the skin-eruption, the pustules ought daily to be coated with benzoated lard, or eucalyptolised vaseline, especially during the "scabbing" stage. All crusts when shed ought to be carefully burned.

Scarlet Fever. During the acute stage, throat and nasal discharges should be treated as above. During the peeling of epidermis the body of the patient ought to be sponged once or twice daily with equal parts of Sanitas and warm water, and to be washed twice weekly at least with soap and warm water. Special attention ought to be paid to toilet of hair, ears, and flexures of limbs.

The same line of treatment is applicable to measles, German measles, influenza, and whooping-cough.

In Typhus-Fever all discharges are infective. The patient to be treated as above, in respect of skin and other bodily secretions and excretions.

In Enteric Fever the infective matter is chiefly located in the stools and urine, consequently special attention must be paid to their disinfection. At least equal parts of solution of chlorinated lime or of corrosive sublimate to the amount of stool should be mixed therewith. Carbolic acid is not an efficient disinfectant of the *B. typhosus*, unless used very strong. A novel but effective method of sterilising enteric stools has been carried into effect during the

South African campaign by Major Cummins of the Royal Army Medical Corps.[1] As perfected, the method consists in putting into a cauldron fitted with a tight cover, two or more gallons of 1 to 20 carbolic solution which are kept boiling, and with which the contents of the bed-pans from enteric patients are mixed, the contents being kept boiling all the time. As required, the cauldron-contents are partially emptied and replenished with fresh carbolic solution. The boiled excreta might, thereafter, be passed with impunity into drains. Bacteriological examination showed that the contents of the cauldron were absolutely sterile. The system was further extended by treating all stools and urine from all patients who were confined to bed, as well as the ward sweepings. The process is simple and effective, and is very applicable to isolation-hospitals as well as to private practice, and entirely does away with the need for other forms of chemical disinfectants, the effects of which in the disinfection of stools especially are apt to be haphazard.

The discharges in Cholera ought to be similarly dealt with. In Diphtheria the infective matter proceeds solely from the mucous discharges and false membrane situated in the nasal tract, pharynx, or air-passages. All such should be carefully burned. In Puerperal Fever the infectivity is located mainly in the discharges from the genital tract. These ought to be received on antiseptic napkins or wood-wool pads, and the whole burned together. Body clothing should be steeped in corrosive sublimate solution for some time, allowed to drip, and then placed in fresh water before being boiled and washed. In tubercular pulmonary phthisis the sputum should be received on paper or rags, or into a spittoon containing sawdust, and the paper, rags, or sawdust burned.

In order to effectively disinfect semi-solid, pultaceous, and viscid discharges, it is necessary either to mix mechanically the needed amount of disinfectant with the excretion, or to allow the disinfectant to soak for about an hour, in order that germicidal action may take place in the mass before the mixture is emptied into the slop- or water-closet, which thereafter should be freely flushed. Solutions of mercuric chloride are very apt to fail in their action unless mechanical mixture is made, owing to the formation of albuminates of mercury on the surface of the excretion, especially if they are semi-solid or pultaceous.

After the patient has recovered, he is removed to another room in order that the apartment he has left and its contents may undergo disinfection. Immediately prior to removal, however, he should be washed, clothed in a fresh warmed blanket which has been handed in for the purpose, and then reclothed on arrival in the new room. In scarlet fever and in diphtheria especially, the patient should use for some time after apparent recovery, some form of antiseptic gargle to destroy lingering organisms. The vacated room and its contents now require to be disinfected. The clothing which the patient has left behind, that of the nurse, the bed-clothing, and the room-furnishings must be disinfected either by the householder, or by the Sanitary Authority. In rural districts and villages it usually falls to be done by the householder; in populous districts it is commonly done by the Sanitary Authority. The householder should be instructed how to carry out the process. All articles of clothing, bed-clothing, etc., should be steeped in the room for a couple of hours in a solution of 1 to 2000 corrosive sublimate, should then be roughly wrung, and in a covered vessel be removed to the wash-house, there to be submitted to boiling and the usual cleansing process, after which they should be exposed in the open air for twenty-four hours. Mattresses, pillows, cushions, etc., should be left in the room to be disinfected by a gaseous disinfectant, and, after being sponged over with 1 to 40 carbolic acid solution, should thereafter be removed into the open to a place a little distance from the house, and be left exposed to the air under cover if need be for several days. Mattresses soaked with discharges cannot be disinfected in this way, and therefore ought to be burned.

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[1] *B.M.J.*, vol. ii., 1900, p. 1369.

as should also any worn-out clothing. In smallpox, especially in confluent and fatal cases, mattresses ought to be burned whether old or new. The woodwork, floor, furniture of the room, and the walls and ceiling fall next to be dealt with. These are usually exposed to the action of a gaseous disinfectant, of which sulphurous acid and formaldehyde are perhaps the most practicable. Gaseous disinfectants have been hitherto used for disinfection of the air of the room, but this so-called aerial disinfection is at best but a delusion, for if ventilation of the room has been attended to, little fear need be entertained of its infectivity. What do demand attention, however, are the microbes and spores which have become constituent parts of the dust which has settled in the crevices, corners, and other points of lodgment in the room. In Continental countries little or no attention is paid to aerial disinfection, while much is paid to the deposited dust. Hence two methods of room-disinfection prevail: one devoted mainly to aerial disinfection, as in Great Britain, the other to disinfection of room-dust, as in France and Germany. Each method requires further description.

The English Local Government Board recommends that 1½ lbs. of sulphur, mixed with a liquid combustible as alcohol, or a solid, as nitre, should be burned for each 1000 cubic feet of air-space in the room which has been made as air-tight as possible, and the sulphurous acid gas which is produced allowed to act for 24 hours. But this only produces in the space named 1·75 per cent. of gas, whereas direct experiment shows that 4 per cent. are necessary. Apart from this, however, to burn solid or powdered sulphur is not an easy matter. This uncertainty of action, however, is overcome by the use of cylinders or siphons of compressed liquid sulphurous acid gas. The gas is compressed at a pressure of about 45 lbs. per square inch, and it is liberated by cutting the projecting soft lead pipe. Before using sulphurous acid, and in order to make its action efficient, the apartment and the contained articles ought to be moistened with water, otherwise much of its potency is lost. Instead of this gas, chlorine is sometimes substituted. But in order to generate the necessary lethal amount from chlorinated lime, it is necessary to use 15 lbs. of that substance and 22 lbs. of hydrochloric acid per 1000 cubic feet of space, which is impracticable. Doubtless when it is manufactured in the compressed liquid form it will be more serviceable, although it corrodes metallic objects and its fumes are exceedingly pungent and irritating. A very potent gaseous germicide, however, has been discovered in methylaldehyde or formaldehyde (CH_2O), commonly met with as formalin—a 40 per cent. solution of the former in water—which is the highest percentage capable of being dissolved in that medium. As sold commercially, it may be slightly acid in reaction due to traces of formic acid. Discovered by A. W. Hoffmann in 1867, it was not till 1886, however, that its germicidal properties were revealed by Loew and Fischer, and not till 1892 that attention to its practical use as a disinfectant was attracted by a communication to the French Academy of Sciences by Trillat. Since that time it has been largely used as a preservative of milk and other foods. If attempts are made to concentrate the watery solution or to condense the vapour, a solid substance is formed, crystalline in character, called *paraformaldehyde* ($C_3H_6O_3$), which when heated melts at 171° C., but on heating it gently vaporises into gaseous formaldehyde. When borax or chloride of calcium, however, is added to formalin, and the mixture is heated under pressure in a closed vessel, the above change does not ensue. Formalin does not possess an offensive odour, but formaldehyde vapour is very pungent and irritating, and its odour is apt to be lasting. It acts upon albuminous substances and forms compounds with them; for example, it changes egg-albumen into a substance insoluble in water. The vapour or liquid does not attack metals, does not act prejudicially upon delicate articles of attire or furniture, and does not bleach colours. Its action is very lethal upon micro-organisms when used either as a vapour or as a liquid. The vapour is generated by means of autoclaves, lamps, or generators, and is dissipated either in the form of pure vapour or of vapour mixed with steam, and the substances used are either liquid formalin, or the solid substance paraformaldehyde, or *paraform* as it is called commercially. Of the many forms of apparatus which have been devised, the principles of their action may be used to divide them into three classes—viz. (*a*) those in which the pure vapour is driven off from liquid formalin under pressure or without pressure ; (*b*) those in which combined vapour and steam are disengaged ; (*c*) those in which the vapour is liberated from solid tablets of paraformaldehyde. Trillat's autoclave may be taken as a type of the first. It consists of a reservoir to hold the formalin, to which chloride of calcium is added to prevent polymerisation, the mixture being called formochloral ; a pressure-gauge ; thermometer ; an outlet whereby the gas escapes which is regulated by a valve ; and a lamp. When the apparatus is to be used, the cover of the reservoir is bound down, the lamp is lit, and the formaldehyde vapour passed by means of the keyhole into the room to be disinfected. The instrument of the Sanitary Construction Company acts without pressure, since the formaldehyde is passed in regulated supply into a heated coil and is thus rapidly vaporised. The Breslau generator may be taken as a type of the second class. From it is generated a mixture of the vapour and steam, the boiling solution used being a mixture of one part of formalin and four of water. The solution is heated by a spirit lamp, and the amount of spirit to be used should be in proportion of one-fourth of the volume of the disinfecting solution, so that the heating should be exhausted before the complete vaporisation of the solution. The Schering generator is a type of the third class. In it the solid paraformaldehyde is used in the form of tablets, each of the weight of one gramme. The requisite number of tablets is placed in a basket made of iron and wire gauze over a spirit lamp of several wicks, both being surrounded by an open-mouthed iron casing. Into the lamp are put 2 c.c. of spirit for each tablet used, and the wicks only project $\frac{1}{12}$th of an inch, so as to give just the amount of heat necessary to volatilise the tablets, and to prevent the possibility of burning them. In addition to these forms of apparatus may be added another which was advocated by Schlossman[1] and Walther. Schlossman is of opinion that in the methods already described the bulk of the formaldehyde does not escape as such, but is converted into polymers. This polymerisation, he affirms, is prevented in his method by the use of glycerine. Lingner's apparatus to carry out this method consists of a vessel in which water is boiled, from which the steam passes into a reservoir which contains formalin and 10 per cent. glycerine, which mixture is called by them *glycoformal*. From this reservoir four pipes emerge, by which the mixture of steam and glycoformal is made rapidly to fill the room to be disinfected. Schlossman states that a room of 60 cubic metres can be so filled with vapour in 10 minutes that an electric lamp, placed in the centre, can no longer be seen, and that all organisms are killed in about three hours at the outside. The advantages which he claims for his method are : (1) absolute sterilisation ; (2) no danger of explosions ; (3) cheapness ; (4) the total disinfectant powers of the gas are obtained ; (5) and that the operation is complete in three hours. At the end of the time the windows of the room are thrown open for half-an-hour, after which they are again closed, and liquid ammonia is placed in the room to get rid of the odour, then after a short time the room is again thrown open, and the odour of the disinfectant has disappeared. The effect of ammonia upon formalin is to form an inodorous compound, *hexamethylentetramin* ($NH_4 + 6CH_2O = (CH_2)_6N_4 + 6H_2O$). In addition to these methods of disinfection, formalin may be sprayed upon the walls, furniture, etc., of the apartment by different forms of atomisers or pulvérisateurs.

Amount Required for Room-Disinfection.—The general rule, when formalin is vaporised, is to employ a pint (20 ozs.) of the fluid for every 1000 cubic feet of space, and of solid paraformaldehyde, 60 tablets or 60 grammes, with a minimum of exposure of four to ten hours. When used in the form of spray, the strength of solution ought to be 1 part of formalin to 50 of water, and the total quantity used to be regulated by the size of the apartment.

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[1] *Berl. klin. Woch.*, 20th June 1898.

Efficiency.—Diverse opinions have been entertained as to the efficiency of this gaseous disinfectant in respect of its power of penetration, but direct experimentation has proved that it disinfects only surfaces which are smooth or polished, that it is not reliable in its action upon dust, that it does not penetrate the interior of bulky objects as bedding or upholstered furniture, that it requires not less than ten hours to attain its maximum efficiency, and that it is not cheaper than, if indeed as cheap as, other methods. Some experimenters, as Abba, go the length of saying that it cannot be deemed of practical utility as a disinfectant for room-disinfection generally.[1]

Whatever form of gaseous disinfection is employed, the room must be thrown freely open for some time thereafter to permit the odours to be dispelled before further cleansing operations are proceeded with. Thereafter the floor, woodwork, and furniture must be washed with 1 in 1000 corrosive sublimate solution, the wall-paper if present stripped, and if not, the walls and ceiling should be lime-washed, the windows remaining open night and day all the while.

In view of the inefficiency of gaseous disinfectants to sterilise the dust deposited in a room, we come back after all to the conclusion that the prime object to be attacked is the dust, since in it will be located live micro-organisms and spores. There is therefore much to be said in favour of any procedure which initially deals with this dust. The methods adopted in France and Germany are calculated to do this. In Paris, infected rooms are disinfected by a 1 in 1000 corrosive sublimate solution which is distributed all over the apartment and its contained furniture, in the form of a fine spray by means of a *pulvérisateur.* This machine, which is of different sizes, and which may be either carried on the back of the operator or moved about on wheels, according to the amount of work to be done, is operated by the workman, who while he is engaged in the work is clad in an overall uniform, which when the work is done is taken off, packed in a small tin case, and then returned to the disinfecting station. The charwoman does the rest. It may be objected to this method that the workmen are exposed to the poisonous effects of the disinfectant; but notwithstanding the many thousands of operations which are performed annually, little evidence of toxic effects has been seen. This is a risk, however, demanding attention. But if, as in Paris, the workmen are instructed as to the poisonous nature of the solution, such risks are reduced to a minimum. No harmful effects on the inmates have been recorded after re-occupation of rooms so treated.

Esmarch's method, which is carried out in Berlin, is also a method for dealing with the dust. The material used consists of chunks of ordinary German bread forty-eight hours old. These are used by workmen for rubbing down the walls and ceiling of the room, by which the dust adheres to the bread, which is then burned. The walls are then sprayed with a 2½–5 per cent. solution of carbolic acid, the floor, woodwork, and furniture treated with the like solution, in this way accomplishing the disinfection of the room. If the various methods of disinfection are reviewed, it will be apparent that they all involve expenditure of time and money, and that none of them can be done cheaply. Objections may easily be offered to any one plan as compared with another, but if disinfection is not to be merely a name, then both labour and money must be expended. We are of opinion that spraying operations are by far the most likely to be effective as they are certainly the most rational, since the dust is attacked and prevented from becoming air-borne, and that gaseous disinfection should be abandoned. Such methods of disinfection have also the merit that they compel the cleansing of the whole room; and there can be little doubt that much disinfection is achieved by the liberal use of soap and water, and the freedom with which air is allowed to circulate in the apartment while cleaning operations are being carried on.

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[1] *Centralbl. f. Bakt.*, Band xxviii., Nos. 12, 13, 1900.

Standardisation of Disinfectants.—The need for some method of gauging the actual disinfecting value, and, therefore, the trustworthiness of preparations put on the market which are sold as disinfectants, has occupied for many years the attention of sanitarians, since if disinfection is to be worthy the name it is all-important that sanitary authorities and the public generally should have reliable preparations at their call. Probably among the earliest to suggest a method of standardisation was Moor,[1] who proposed that the standard to be employed should be the resisting power of a given organism to certain dilutions of a given disinfectant under consideration, compared with the resisting power of the same organism from the same culture to (*a*) a 1 : 1000 solution of corrosive sublimate, and (*b*) a 5 per cent. solution of carbolic acid, each at a temperature of about 15° C.

In 1903, Dr Rideal and Mr Ainslie Walker[2] made the further suggestion that the ratio of the strengths in which a given disinfectant would effect sterilisation of a given organism to that of the strength of a dilution of carbolic acid which would produce the same result in the same time, might form a practical measure or test of the efficiency or germicidal potency of the disinfectant. The standard employed is a dilution of one part of carbolic acid in 100 parts of sterile water. Pure crystals of carbolic acid contain about 7 per cent. to 9 per cent. of water, hence 110 parts by weight of the B. P. acid may be taken as equivalent to 100 parts by weight of pure phenol. If greater exactitude than this be desired, it would then be necessary, by titration against a standard solution of bromine, to find the exact value of the pure phenol per hundred parts of the sample of acid to be used.

Since the value of the Walker-Rideal or Rideal-Walker test depends upon the complete parallelism of conditions which are maintained throughout the test, these observers have set down definitely the steps which have to be followed and the conditions to be observed. Put briefly the test is this :—To 5 c.c. of a particular dilution of the given disinfectant in sterilised water are added 5 drops of a 24-hours' blood-heat-incubated, vigorous-growing culture of the organism in broth. Shake to mix thoroughly, and take sub-cultures therefrom every $2\frac{1}{2}$ minutes up to 15 minutes. If 30 seconds be allowed for each admixture, or act of medication as Rideal and Walker call it, and the same time for taking each sub-culture, four different dilutions of the given disinfectant together with one standard control of solution of carbolic acid may be tested against the same culture, under conditions which make the results as nearly comparable as may be. The germicidal potency of the given disinfectant is expressed in multiples of carbolic acid performing the same work in the same time, or as a fraction in which the dilution of the standard control 1 : 100 is the denominator, and that of the given disinfectant is the numerator ; thus, if the dilution of the disinfectant which destroyed the organisms in the same time as that of carbolic acid was 1 : 1000, then the fraction would be $\frac{1000}{100}=10$, and this figure would be the "carbolic acid co-efficient," or as it has now come to be called, the "Rideal-Walker co-efficient."

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[1] *Applied Bacteriology*, 1896, p. 285.

[2] *Jour. Roy. San. Instit.*, Part III., p. 424.

In any experiment or test the *time* must be taken as the *constant*, and the *strength or degree of dilution of the disinfectant* as the *variant*. The test-organism employed by Rideal and Walker is *B. typhosus*, grown in broth and incubated for 24 hours at 37° C. The reason why a broth culture is preferred is that its composition is more likely to be uniform. Variability in composition of the culture-fluid would lead to probable error. Five drops of such a culture, therefore, is the amount to be added to each dilution. The sub-cultures taken from the dilution-mixtures at the end of the respective time-periods of exposure are to be incubated at 37° C. for not less than 48 hours.

Others have suggested that instead of adding the culture directly to the dilutions, the organisms should be exposed on an intermediate substance, such, for example, as threads, or garnets. Paul and König suggested the use of small garnets of equal size, which should be treated with a vigorous liquid culture of the organism by immersion, then removed from the medium, dried, and in the dried condition should be placed in the dilutions of the disinfectant and of the carbolic acid control. After each garnet has been exposed to the influence of the dilution for its appropriate time-limit, it is to be removed therefrom and thoroughly washed in sterile water, from which cultures are to be made and incubated just as in the other process. In our view, such a method merely multiplies the steps of the technique of the test and the sources of probable error, and offers no advantages over the Rideal-Walker method. Whatever value either of these processes possesses is due entirely to the completeness of parallelism of conditions observed throughout the test.

The most pertinent objection to such a test as the foregoing, whatever its precise technique may be, is that any results obtained from it can only be esteemed as approximations to the actual germicidal values of the substances when practically applied. It is one thing to determine the bactericidal power of a disinfectant under conditions such as those described, and quite another to estimate the value of that power when used in liquids or solids of an organic character. This is well illustrated by an example which has been recorded by Bickel and Kraus.[1] These investigators were examining the disinfecting potentialities of three preparations of cresol, namely, saprol, linseed-oil and cresol, and petroleum cresol. Linseed-oil, when mixed with raw cresol in equal parts, forms a homogeneous mixture. Petroleum also forms a mixture with cresol which, when floated over a fluid, allows the cresol to separate out gradually and to be dispersed throughout the fluid. Their disinfecting value was determined by the method of Paul and König, the organisms used being staphylococci, and the strengths of the dilutions used 1 : 100 and : 1 50, ammonia being employed to neutralise the disinfectant at the expiration of test-time. After 5 minutes' exposure to the 1 : 100 dilution, only two colonies developed within two days from each of five garnets when saprol was used, twenty-two colonies when petroleum cresol was used, and 160 colonies with linseed-oil cresol. When *B. typhosus* and *B. choleræ Asiaticæ* were substituted, suspended in normal saline solution, practically no difference in disinfectant value of the three preparations was found. When, however, these organisms were suspended in solutions of fæces, they resisted the action of the disinfectants for longer periods: thus, *B. typhosus* lived for four or five days in the normal saline solution when covered with each of the three disinfectants, and for eight days when in the fæcal solutions. Having said this, however, we are bound to acknowledge that the Rideal-Walker test is the best workable test for the estimation of the relative bactericidal values of disinfectants.

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[1] *Arbeit. a. d. Kaiserl. Gesund.*, Band xxvi., H. 2, 1907; *B.M.J.*, vol. ii., 1907, s., p. 79.

CHAPTER XIII

SANITARY LAW RELATING TO INFECTIVE DISEASES

It is essential that medical practitioners should have some knowledge of the laws relating to infective diseases, not only for their own guidance, but also to enable them to advise their clients when such advice is asked. The main provisions of all Acts of Parliament dealing with sanitary matters are intended to conserve the public health by the removal of all causes which may imperil it, and to prevent the origin and spread of infective diseases.

In none of the Public Health Acts is there any definition of what constitutes an infectious disease, notwithstanding that such diseases are mentioned in various Acts.

In 1889, the Infectious Disease (Notification) Act, 1889,—52 & 53 Vict. cap. 72—became law, and for the purposes of the Act a scheduled list of infective diseases was given. The diseases embraced in the schedule are the following—viz. smallpox, cholera, diphtheria, membranous croup, erysipelas, scarlatina or scarlet fever, and typhus, typhoid, enteric, relapsing, continued, and puerperal fevers. It will be observed that some of the other infective diseases as measles, whooping-cough, chicken-pox, influenza, plague, and others, are not included; but a Local Authority may, by provision of section 7 of the Act, after due resolution and publication of its intention, add one or more of the above to the list; indeed, this has been done by various Local Authorities in respect of measles, choleraic diarrhœa, plague, cerebro-spinal meningitis, and others.

The terms of section 7 are as follow :—

(1) The Local Authority of any district to which this Act extends may, from time to time, by a resolution passed at a meeting of such Authority, where special notice of the meeting and of the intention to propose such resolution has been given fourteen clear days before, order that this Act shall apply in their district to any infectious disease other than a disease specifically mentioned in this Act.

(2) Such order may be permanent or temporary, and if temporary, the period shall be specified therein, and any such order may be revoked or varied by the Local Authority.

(3) Any order under this section shall not be valid until approved by the Local Government Board.

(4) When such order is so approved, the Local Authority shall advertise the same in a local newspaper and by handbills and otherwise in such manner as the Authority think sufficient to inform all persons interested. They shall send a copy thereof to each registered medical practitioner known to be residing or practising in their district.

(5) Such order shall come into operation not earlier than one week

after publication of the first advertisement, and so long as the order is in operation the infectious disease mentioned therein shall be an infectious disease to which this Act applies.

(6) In the case of emergency three clear days' notice under this section shall be sufficient, and the resolution shall declare the cause of such emergency and shall be for a temporary order, and a copy thereof shall be forthwith sent to the L. G. Board, and advertised, and the order shall come into operation at the expiration of one week from the date of such advertisement, but unless approved by the L. G. Board shall cease to be in force at the expiration of one month after it is passed, or any earlier date fixed by the L. G. Board.

(7) The approval of the L. G. Board shall be conclusive evidence that the case was one of emergency.

The burden of notifying the existence in a house of one or other of the infective diseases above named falls upon (1) the head of the family or other responsible person, and (2) upon the medical practitioner in attendance. Failure to perform this duty is penalised after conviction by a fine not exceeding forty shillings. Section 4 provides that duly printed forms for notification purposes shall be sent to each medical practitioner, who shall, for the notification of disease in respect of each case in private practice, or for each case in his practice as medical officer of any public body or institution, receive a fee of two shillings and sixpence or one shilling respectively.

The Act being a permissive or adoptive Act, section 5 records the procedure for its adoption by an urban or rural district; and section 7, the procedure by which an addition to the scheduled list of diseases may be made. In Scotland, however, by section 44 of The Public Health (Scotland) Act, 1897, the adoption of the Notification Act is compulsory upon all Local Authorities, and in England and Wales by The Infectious Diseases Notification (Extension) Act, 1899. The Act is still adoptive in Ireland. The payment of fees under this Act to a medical practitioner does not, in terms of section 11, disqualify him for serving as member of the council of a county or borough, or in other like capacity, nor even although he himself is the medical officer of health is he debarred from receiving fees. The Notification Act applies to the United Kingdom.

The provisions of the Public Health Acts in which the medical practitioner has especial interest are those which deal (1) with the infective person; (2) with the infective place; (3) with infective things. The subjects may, therefore, be dealt with in that order.

I. In respect of the Infected Person.—It is forbidden, under a penalty, for any person suffering from an infectious disease (1) to wilfully expose himself or for any person to expose anyone suffering, in any public place or conveyance, without taking proper precautions against spreading the disease; (2) to enter a public conveyance or ship, or to cause an infected person to be conveyed in such way; (3) to be conveyed knowingly by the owner or person in charge of such conveyance or ship, unless the fact is at once notified to the Sanitary Authority and the conveyance thereafter disinfected by the Local Authority. (It is not forbidden, however, for infective persons to travel by railway-train or by ship, if they are conveyed within an ambulance-waggon or other vehicle provided or approved by the Local Authority); (4) to engage, knowing that he is suffering from such disease or is living in an infected house, in the operation of milking any animal, of picking fruit, or in connection with any trade or business calculated to spread disease; (5) for a parent or other person in care or charge of a child who is or has been suffering from such disease, or who resides in a house where such disease is or has been existent within a period of three months, to knowingly or negligently permit such child to attend school without a certificate from the medical officer of health or a qualified medical practitioner that such child is free from disease and infection, and that the house and contents exposed to infection have been duly disinfected, under a penalty not exceeding forty shillings. The teacher or person in charge of the school is culpable in the same case, the penalty being the same. The P. H. Acts Amendment Act, 1907 (adoptive), section 58, gives power to a Local Authority to call upon the principal of a school in which any scholar is suffering from an infectious disease, to furnish a list of names and addresses of the scholars other than boarders.

Removal of Infected Persons.—Where an isolation-hospital has been provided in any urban or rural district, any person suffering from such disease who is without proper lodging or accommodation, or who is lodged in a room occupied by others than those in attendance, or who is on board any ship or vessel within three miles of the coast, may, on a warrant by a magistrate, be removed from thence to a hospital, or alternatively, the persons not in attendance upon the patient may be removed from the house by order of the magistrate, in which case the Local Authority must provide suitable accommodation for them. In like manner an infective person in a common lodging-house may be removed to hospital. Such provisions are to be interpreted by the existence or non-existence of means of efficient isolation and facilities for disinfection. All of the foregoing provisions only apply to the living infective person. What of the dead? No precautionary or prohibitory provisions exist in any of the Public Health Acts regarding the removal in a public conveyance from a house to a place of sepulture or cremation of the body of a person who has died of infective disease, provided that the conveyance is one reserved for the purpose. But it is unlawful to transport for burial, or for other recognised means of disposal, the body of a person who has died of infective disease, unless and until it has been certified by the medical officer of health or a legally qualified medical practitioner that precautions requisite for the public safety have been adopted. Moreover, it is penal for an undertaker or any other person to remove in the above way such a body without having obtained the above necessary certificate. While the foregoing is now the law of Scotland (P. H. (Scot.) Act, 1897, section 69, sub-section 3), the law of England and Ireland—Infectious Disease (Prevention) Act, 1890—is exactly the same. Should in any section of the kingdom the vehicle employed for this purpose not be reserved for the carriage of dead bodies, notification that the dead body is infective must be made to the owner or driver thereof, and the vehicle thereafter be disinfected, otherwise it shall be an offence. Where a public mortuary has been provided, and where the body of a person who has died of infectious disease is retained in a room in which persons live or sleep, or is retained longer than 48 hours in a room used as a dwelling-place, sleeping-place, or work-room, or where any dead body is retained in a house, room, or ship under circumstances which might endanger the health of the inmates or of neighbours, such may be removed on warrant to the public mortuary. The duty of interment of such bodies falls upon the Local Authority when the friends or relations of the deceased are unable to do so, or do not inter within the time above specified, in which latter case the Local Authority may recover the expenses from the friends or relations. (Section 69, sub-sections 1 and 2, P. H. (Scot.) Act, 1897.)

Again, in view of the practice of certain persons of "waking" the dead, it has been made penal in the Scots Act (section 56, clause *d*), and in the Public Health Acts Amendment Act, 1907, section 68 (adoptive), if anyone wakes or permits to be waked in any place over which he has control the body of an infective person.

If a person dies in any hospital from any infections disease, and if it be certified by a legally qualified practitioner that in order to prevent the spread of the disease the body should not be removed except for burial, it shall not be removed except to be taken direct to the place of burial. Wilful disobedience carries with it a penalty not exceeding £10. (P. H. (Scot.) Act, s. 63; P. H. (Lond.) Act, 1891, s. 73; and Infectious Disease (Prevention) Act, 1890, s. 9.)

II. In Respect of the Infective Place.—From what has been said, it is incumbent upon the owner or driver of a public conveyance or master of a ship to disinfect the said conveyance or ship as soon as it comes to his knowledge that an infective person has been carried therein; the loss and expense incurred to be recoverable from the person or his friends. The same is true of a public conveyance other than one reserved for the purpose, which has been used for the carriage of a dead body. In like manner the room occupied during an infective illness must be disinfected at the termination thereof, either: (1) by the householder himself at his own expense, and to the satisfaction of a legally qualified medical practitioner; or (2) by the Local Authority.

Any person who lets for hire, or shows for the purpose of letting, any house or part thereof, and who on being questioned by the person negotiating for the hire as to whether within the previous six weeks infective disease existed therein, makes a false answer, shall be liable to a fine not exceeding £20, or imprisonment, with or without hard labour, for a period not exceeding one month (P. H. (Scot.) Act, s. 52; P. H. (London) Act, 1891, s. 64); any person who, after occupying a house or part thereof in which infective disease has existed within six weeks previously, fails to have the house and its contents disinfected, or to give to the owner or occupier notice of the existence of said disease, or who makes a false answer on being questioned regarding said existence, shall be liable to a like monetary penalty; and anyone who knowingly lets for hire any house or part thereof in which infectious disease has existed, without house and contents having been disinfected to the satisfaction and upon the certification of a legally qualified practitioner, is liable also to a like penalty. This section (51, sub-section 2) includes the keeper of an inn or hotel (p. 472). A like provision is contained in the Infectious Disease (Prevention) Act, 1890, section 7.

III. In Respect of Infective Things.—Anyone who gives, lends, sells, pawns, transmits, removes, or exposes, or permits to be washed or exposed in any wash-house or washing-green which is used in common by persons other than the family or household to which the infected person belongs, any bedding, clothing, or other articles which have been exposed to infection, without previous disinfection, shall be liable to a penalty not exceeding five pounds (P. H. (Scot.) Act, s. 56; P. H. (Lond.) Act, s. 68). This does not apply to articles transmitted under proper precautions for purposes of disinfection. Section 47 of the P. H. (Scot.) Act, 1897, deals with the need of disinfecting all articles in a house which have been exposed to infection on notice being served upon the occupant or owner by the Local Authority, and sub-section 5 authorises said Local Authority to compensate said occupier or owner for any unnecessary damage caused to such articles on being disinfected by said Local Authority; section 48 deals with the disinfection or destruction of bedding, clothing, etc., on notice being served for the delivery thereof to an officer of the Local Authority, and sub-section 2 authorises compensation; section 49 compels, on proper cause shown, persons engaged in washing or mangling clothes to furnish a list of owners of clothes; and section 50 penalises anyone who knowingly casts, or causes or permits to be cast, into any ash-pit or otherwise exposes any matter or article infected by infectious disease, for each offence and continuance of the offence. The following may be taken as illustrative cases—viz. (1) trafficking in any article from any infected room; (2) carrying infected articles through the public streets, or sending the same in a public conveyance; (3) washing infected clothing in a wash-house which is common to other houses, or sending the same to a public laundry; (4) making fabrics for warehouses or for private persons in an infected house, and transmitting the same to the warehouse or private person when made; (5) pawning infective articles; (6) selling food of any kind in a shop attached to a dwelling-house in which infective disease exists; and (7) transmitting infected bedding or furniture to upholsterers or public cleaning-establishments. The term "matter infected by infectious disease" would include such things as excreta, poultices, wall-paper, or vomited matters which are cast into a receptacle in a public place without previous disinfection. Where a medical officer of health has evidence that persons in his district are suffering from diseases that are attributable to the milk-supply from any dairy, or that the milk from any such dairy is likely to cause or to have caused such disease, he shall visit the dairy and examine every person connected therewith, and a veterinary inspector shall examine the animals therein and report to the Committee of the Local Authority (P. H. (Scot.) Act, s. 60; P. H. (Lond.) Act, s. 71—Infectious Disease (Prevention) Act, s. 4). Sub-section 2 of the Scottish Act gives the medical officer of health power, when required, to communicate with the Local Authority of the district whence the milk has come to any dairy in question, and such Local Authority shall be bound forthwith, by its medical officer, to examine said dairy which is suspected and the persons connected therewith, and by a veterinary surgeon, to examine the animals therein, and the medical officer of health of the second-mentioned Local Authority shall forthwith report the results of said examination along with the report of the veterinary surgeon to the first-mentioned Local Authority; sub-section 3 gives a Local Authority power to order the dairyman to cease the supply of milk, where the facts warrant such a step, for such time as may be deemed necessary. Section 61 empowers the Local Authority, on the fact being certified that the outbreak or spread of infectious disease is attributable to milk supplied from a dairy or dairies, to demand from the dairyman, whether within or without its district, a full and complete list of the names and addresses of all his customers within its district so far as known to him, for which the dairyman shall be remunerated on a scale laid down in this section.

A like provision is made for England in section 53 of the P. H. Acts Amendment Act, 1907 (adoptive). In this Act a provision, new to public health legislation, has been enacted—viz. To prevent infective persons taking or using any book from any public or circulating library, or any person permitting any such book to be used by an infective person, or returning any such book which has been so used to any such library without giving notice to the Local Authority, so that the Local Authority may destroy the book and compensate the owner of the library, or disinfect it and return it to the library. (Section 59, P. H. Acts Amendment Act, 1907 (adoptive).)

By the regulations as to Cholera, Yellow Fever, and Plague, issued by the Local Government Boards, and which Regulations of the Scottish Board became law in Scotland in January 1898, amended by the Order of 1903, and the Regulations of the English Board became law in England and Wales in November 1896, as amended by the Order of 1902, certain important duties are placed upon Local Authorities having a seaboard, or having a part of their district abutting upon a port. These duties may be briefly summarised as follow:—The Regulations deal (1) with ships' crews and passengers, and with ships coming from infected ports; (2) with ships having on board passengers in a filthy or otherwise unwholesome condition; (3) with the bilge-water, water-ballast, and water-supply of ships. The Regulations of the English Board were issued in virtue of section 130 of the Public Health Act, 1875, and those of the Scottish Board in terms of the powers contained in section 78, Part IV., of the Public Health (Scotland) Act, 1897.

It is enacted that the master of every ship infected with Cholera, Plague, or Yellow Fever shall, when within three miles of the coast, cause a large flag of yellow and black, borne quarterly, to be hoisted at the mast-head, and shall keep it hoisted the whole time between sunrise and sunset, and that no person shall leave such ship until it shall have been visited by the Customs Officer and the Medical Officer of Health. Any ship is deemed infected in which, during the voyage or during its stay in the port of departure or in a port of call, there is or has been any case of the diseases named in the Regulations. During the currency of the Regulations, the following procedure shall be adopted in respect of any ship arriving from foreign ports—viz. It shall be visited by the Officer of Customs who shall ascertain whether or not said ship is infected, and if he has reason to suspect that the ship is infected, shall require the master or surgeon of the ship, if there be one, to give in writing a true answer to the question—viz. whether any case of the diseases named in the Regulations has occurred in the ship at any point of its progress. If the ship is infected, or there is reason to suspect this, the Customs Officer shall order the ship to be moored in such position as he shall direct, during which period of detention no one shall leave the ship. Thereupon the Customs Officer shall give notice to the Local Authority of these facts, and thereafter the ship shall be visited by the Medical Officer of Health, who shall at that visit examine every person on board, and in the event of finding any illness due to the above diseases, or likely to develop into such, shall certify in writing accordingly, a copy of which certificate shall be handed to the master of the ship, and he shall retain the original, or transmit it to the Local Authority, which is held bound to inform likewise the Local Government Board. Every person suffering from one or other of the diseases named shall, if his condition admit, be removed to a hospital or other suitable place set apart for the purpose by the Local Authority; if on the other hand the patient be too ill to be removed, the ship shall remain subject to the control of the Medical Officer of Health, and the patient shall not be removed from or leave the ship except with the consent in writing of the said Medical Officer. Persons suffering from suspicious illness may either be detained on board for a period not exceeding two days, or be taken to hospital and detained there for a like period for probation. No person on board an infected ship shall be allowed to land unless he satisfy the Medical Officer of Health as to his name, destination, and address, whereupon the Medical Officer shall forthwith transmit the name, etc., of each such person to the Clerk to the Local Authority, who in his turn shall transmit the same to the Local Authority of the District in which such intended place of destination is situated. Every such person, who within 48 hours of landing shall arrive at any destination or address other than that given, is bound upon arrival forthwith to notify in writing his destination and address to the Medical Officer of Health, or to the Local Authority of the District in which his address is located. The Medical Officer of Health, in the case of every infected ship, shall direct all the necessary steps for disinfection and for prevention of spread of infection, and the master of the ship shall execute such directions. The master shall, in the event of any death from the named diseases taking place on board, either commit the body, properly loaded to prevent its rising, to the deep, or shall deliver it in charge of the Local Authority who shall lawfully and properly dispose of it; he shall cause all clothing, bedding, or other articles likely to retain infection which have been used by the infected person, to be disinfected or destroyed; he shall cause the ship to be disinfected, and every article therein likely to be infected to be disinfected or destroyed, according to the directions of the Medical Officer of Health.

Where a ship is not certified to be infected, but has passengers on board who are in a filthy condition, or has come from a place infected with the named diseases, the Medical Officer of Health may certify accordingly, and shall give a duplicate copy thereof to the master of the ship, and retain the other or transmit it to the Local Authority. In such a case no person on board shall leave or be allowed to leave the ship until the name, intended place of destination, and intended address at such place has been given to the Medical Officer of Health.

Following upon this are the duties of Medical Officer of Health, Clerk to the Local Authority, and of individuals, as have been previously detailed in the case of an infected ship.

If the Medical Officer of Health has reason to believe that any ship coming or being within the jurisdiction of the Local Authority is infected, or has come from an infected place, he may direct that all bilge-water and water-ballast be pumped out in some suitable place before such ship enters any dock or basin, or if any danger be apprehended from such action, as for example, danger to stability of the vessel, he may cause any tank, etc., containing the water-ballast to be sealed and unopened so long as the ship remains within the jurisdiction of the Local Authority. He may also, where the Local Authority provides a proper supply of water for drinking and cooking purposes, direct that all casks or tanks on the ship which contain the water-supply thereof, shall be emptied, cleansed, and thereafter be replenished. The Regulations enact that a Local Authority may appoint one or more legally qualified medical practitioners to act in the execution of this order, either in place of or as an assistant or assistants to the Medical Officer of Health, and may pay such practitioners reasonable remuneration.

Port Sanitary Districts and Authorities.—While by virtue of section 177 of the Public Health (Scotland) Act, 1897, a Local Authority has control, for sanitary administration, over any ship which may lie in any river, harbour, or other water within the area of the Local Authority, or *ex adverso* such harbour, river, etc., and over any ship within three miles of the coast forming the boundary of the area of the Local Authority, further powers have been conferred upon a Local Authority or authorities as Port Sanitary Authority upon the establishment of a Port Sanitary District. The Local Government Board may by Provisional Order constitute any Local Authority whose district or part of it forms a part of or abuts on any part of a port or the waters of such a port, or any persons having authority in or over such port or part of it, "Port Local Authority." Such Port Local Authority may be constituted by a single Local Authority, or by a joint authority of two or more Local Authorities having jurisdiction within the same area (where, for example, a navigable river forms the boundary-line of two counties or burghs), or of representatives of two or more of said Local Authorities. On the institution of a Port Local Authority by the Board by Order, said Order must be forthwith laid before Parliament. The powers conferred upon a Port Local Authority are those which are embraced in the Public Health Acts as referable to houses, with reference to nuisances, structural alterations, as for ventilation of sleeping places, water-storage, etc.

Up till the present time the sole Port Local Authority which has been constituted in Scotland is Glasgow, which made application to the Scottish Local Government Board to be so constituted for the Customs port of Glasgow, regarding which evidence was heard by a Commissioner appointed by the Board in 1903. Powers to do this were only conferred upon the Scottish Local Government Board in the Public Health (Scotland) Act, 1897, secs. 172–176, these having been enacted in like terms to those of the English Act of 1875, secs. 287–292. The Local Government Board constituted in England and Wales, on the other hand, sixty Port Authorities, fifty-eight permanently, and two temporarily. In thirty-four of this total number the administration is vested in a single Local Authority, and in twenty-six in joint Boards.[1]

The essential duties of a Port Local Authority may be comprehended under the following heads—viz.

(1) The institution regarding ships of all those measures which a Sanitary Authority may institute with regard to houses for the preservation of the health of their inmates, and for preventing the spread of infective diseases; (2) the exercise of the Powers conferred upon Local Authorities by the Cholera Orders, viz.: medical inspection of ships, their crews, and passengers with reference to detection of the diseases named in the Orders and of any other infective diseases, the isolation of infective persons, the sanitary condition of the ship itself, the institution of the necessary measures of disinfection, and, generally, quarantine measures—all with the object of preventing infectious disease being spread from ship to port populations, and thence throughout the country.

The duties of a Port Medical Officer of Health have been laid down by a General Order of the English Local Government Board of date 19th June 1893, and those of Port Inspector of Nuisances, by an Order of date 19th July 1883. (*Vide* p. 12.)

Places for the Reception of Persons who have been exposed to Infection, and of Infective Persons.—In order to prevent the spread of infective diseases, the existence of which has been revealed by notification, the Public Health (Scotland) Act, 1897, provides for the establishment of: (*a*) Houses of Reception, and (*b*) Hospitals, the former of which are intended for those who have been exposed to infective disease, but who are not yet, and who may not be, attacked by the disease; the latter, for those who have ben exposed and who already have contracted the disease. The law in Scotland respecting Reception-houses will be found in the following sections of the above Act, in order of sequence, viz.: Sections 47 (sub-section 4); 54, 66 (sub-section 1); and 141. Their purpose will be better revealed, however, if these are discussed in a different order.. Section 66 (1) is to the effect that any Local Authority may, and if required by the Local Government Board shall, provide, furnish, and maintain for the use of the inhabitants of their district suffering from infectious diseases, hospitals, temporary or permanent, and *houses of reception for convalescents from infectious diseases, or for persons who have been exposed to infection*; section 141 authorises a Local Authority to borrow moneys for the above purposes; section 47, sub-section 4 gives the Local Authority power, when deemed necessary, to remove from any house or part thereof, or from any tenement of houses, all or any of the residents not being themselves sick, on account of the existence or recent existence therein of infectious disease, or for the purpose of disinfecting such house or part thereof, or such tenement or part thereof, when, after representation to a Sheriff, magistrate, or justice, said Sheriff, etc., on being satisfied of the necessity for such removal, shall grant the necessary warrant. The Local Authority is by this section empowered to provide temporary shelter or house-accommodation, and, if necessary, maintenance with any necessary attendance, free of charge, for such removed persons during the period of their removal. Section 54 deals with the removal to hospital of infected persons without proper lodging, and also enacts as an alternative measure that the magistrate may direct the removal from the room or house occupied by such persons of all others not in attendance on him, the Local Authority to provide suitable accommodation for such person or persons. Reception-houses are thus obviously intended to act as one of the preventive measures against the spread of infective diseases, and may be reckoned as a necessary integral part of the sanitary equipment of a well-constituted Local Authority. Exposure to infection and impossibility of disinfection of the homes unless vacated are the gauges by which a Local Authority may test its powers of removal. Assuming that persons so exposed are removed, under what condition are they to be treated ? The object and intention of removal being to discover whether from such exposure the disease will develop in those exposed, it is therefore necessary to keep the persons under regulated observation for such periods as will overlap the incubation-periods of the diseases to which they have been exposed. During the period of detention, however, according to the present interpretation of the law, no control over the movements of those received, except as regards decency and order, can be exercised. Accordingly, in certain populous places such persons are allowed to go about in public as they will, even to attend their employment.

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[1] Reports and Papers on the Port and Riparian Sanitary Survey of England and Wales, 1893–1894, issued by the Local Government Board, 1895.

There can be little doubt as to the advisability of conferring upon Local Authorities the powers of compulsory detention and isolation of such persons, with respect at least to certain of the infective diseases. Even with compulsory powers of isolation, Reception-houses should be so placed that a small area of surrounding land, for purposes of exercise and recreation of the inmates, should act as a zone of separation from the outside community ; they should be placed on the outskirts of a town or city ; the inmates should be medically inspected daily, and thermometric observations made twice daily ; each house should possess an isolation-room for the prompt isolation of any inmate who is attacked by a suspicious febrile illness, since in the absence of such provision the Reception-house would itself become an infected place within the meaning of the Act, and would thus expose the other inmates to a prolonged extension of the period of quarantine. Further, families who have been removed by reason of exposure to one infective disease should not be allowed, owing to the risks of new infection, to mix with other families who have been exposed to another infective disease, as is too often the case. In short, if Reception-houses are to form a really valuable factor in the prevention of spread of infective diseases, the regulations regarding them must largely be recast.[1]

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[1] " Reception-Houses." Paper by the Author, *Trans. San. Ass. of Scot.*, 1901.

CHAPTER XIV

LAW RESPECTING INFECTIOUS DISEASES—PREVENTION AND MITIGATION—IN ENGLAND AND SCOTLAND

England.

The Acts of Parliament relating to this subject in England are the following—viz.

I. Public Health Act, 1875; Sections 120–130.

II. Infectious Disease (Prevention) Act, 1890. Whole Act.

(Adoptive to sanitary districts in England, other than London in which it is statutorily obligatory.)

III. Public Health Acts Amendment Act, 1907; Part IV., Sections 52–68.

(Applicable to Sanitary Districts by Order of Local Government Board on application of any Local Authority.)

IV. Infectious Disease (Notification) Act, 1889.

V. Infectious Disease Notification Extension Act, 1899.

Scotland.

The Acts of Parliament in Scotland are :

I. Public Health (Scotland) Act, 1897; Part III., Sections 44–65;
,, 67–71.
Prevention of Epidemic Diseases; Part IV. ,, 78–87.
II. Public Health (Scotland) Amendment Act, 1907. Whole Act.

An effort has been made in the succeeding pages to correlate the law in England and Scotland with respect to the provisions contained therein, so that the student may the more readily grasp the subject.

Infectious Diseases.—Prevention and Mitigation.

Public Health (Scotland) Act, 1897; Part III., Sections 44–65; Sections 67–71.

Section 44. Enacts that the provisions of the Infectious Disease (Notification) Act, 1889, shall extend to and take effect in every district of Scotland, whether adopted or not before the commencement of this Act.

Notification of Infectious Disease.

Section 45. Gives power to the M. O. H., at reasonable times in the daytime, to enter, and inspect any house or premises in the district in which he has reason to believe that any infectious disease exists, or has recently existed, and to examine any person found on such premises to ascertain whether such person is or has been suffering from any infectious disease. In the event of admission, co-inspection, or examination being refused, the Sheriff, magistrate, or justice may, on reasonable cause shown, grant warrant for such entry, inspection, and examination, and on such warrant being obtained and exhibited, any person refusing to admit the Medical Officer, or obstructing him in making the inspection or examination, shall be liable to a penalty.

Empowers the M. O. H. to enter and inspect premises where infectious disease is supposed to exist, and to examine persons therein.

[*Note.*—The term "infectious disease" herein used does not appear to be restricted to the diseases notifiable in the Notification Act.]

Makes Provision for the removal, and destruction or disinfection and return of infected articles.

Section 46. (1) Enacts that every Local Authority may, and when required by the L. G. Board shall, provide either within or without their district, proper premises and necessary apparatus and attendance for the destruction and for the disinfection, and carriages and vessels for the removal, of articles (whether bedding, clothing, or other) which have become infected by any infectious disease, and shall cause any such articles to be destroyed, or to be disinfected and returned, and may remove, may destroy, or may disinfect and return the same free of charge.

(2) Local Authorities may combine for these purposes, or one Authority may contract with another having the necessary apparatus and appliances for these purposes.

[*Note.*—The first part of this section is, in general terms, alike to section 6 of the Infectious Disease (Prevention) Act, 1890, and to section 59 of the Public Health (London) Act, 1891.]

Power to cleanse and disinfect premises and articles.

Section 47. (1) Where it appears to the Local Authority, upon the certificate of the Medical Officer or any other legally qualified medical practitioner, that the cleansing and disinfection of any house and of any articles therein likely to retain infection, would tend to prevent or check any infectious disease, such Authority may serve notice on the occupier of such house, or if the house be unoccupied on the owner, that the house or any such articles therein will be cleansed and disinfected, or (as regards the articles) destroyed, by the Local Authority, unless such person informs the Local Authority that, within a time specified in the notice after its receipt, he will do the work required to the satisfaction of the Medical Officer or of a practitioner, as testified by certificate, within a time fixed in the notice.

[*Note.*—This section is alike in terms to section 5 of the Infectious Disease (Prevention) Act, 1890, and to section 60 of the Public Health (London) Act, 1891.

Where section 5 of the former Act is adopted in any district, section 120 of the Public Health Act, 1875, shall be repealed.]

In case of non-compliance of occupier or owner, Local Authority to carry out disinfection.

(2) If such owner or occupier, within the time specified in such notice, fails to inform the Local Authority as aforesaid; or having informed the Local Authority, fails to perform within the time fixed in the notice; or where such occupier or owner, without such notice, gives his consent; the house and articles shall be dealt with by the officers of, and at the cost of, the Local Authority.

(3) To carry into effect the purpose of this section, the Local Authority may enter by day on any premises.

Local Authority empowered to remove residents, not sick, from premises, on account of existence of infectious disease therein.

(4) If the Local Authority deem it necessary to remove from any house or part thereof, or from any tenement of houses, all or any of the residents not being themselves sick, on account of the existence or recent existence therein of infectious disease, or for the purpose of disinfecting such house or tenement or parts thereof, they may make application to a Sheriff, magistrate, or justice, and the Sheriff, magistrate, or justice, if satisfied of the necessity of such removal, may grant a warrant authorising the Local Authority to remove such residents, and imposing such conditions as to time and otherwise as to him may seem fit. Provided always that no such warrant shall be necessary when the removal is carried out with consent.

Local Authority to provide shelter, etc., to those removed.

The Local Authority shall, and they are hereby empowered to, provide temporary shelter or house-accommodation, and, if necessary, maintenance with necessary attendants, free of charge, for such persons while prevented from returning to such house or tenement or parts thereof.

[*Note.*—Section 15 of the Infectious Disease (Prevention) Act, 1875, is in like terms, but it applies only to one family.]

(5) When the Local Authority have disinfected any house or any article, as hereinbefore provided, they shall compensate the occupier or owner for any unnecessary damage thereby caused to such house or article; and when the Authority destroy any article they shall reasonably compensate the owner thereof.

For the purpose of this section the word " house " shall include any tent or van or any ship lying in any sea, river, harbour, or other water, or *ex adverso* of any place within the limits of the Local Authority.

[Sub-section 5 of this section is akin in terms to section 6 of the Infectious Disease (Prevention) Act, 1890.

Sub-section 1 of this section corresponds in terms to section 120 of the Public Health Act, 1875.

Section 56 of the Public Health Acts Amendment Act, 1907, is in terms alike generally to sub-sections 1 and 5 of this section, but it deals only with the need for cleansing, purification, or destruction of any articles in a dwelling-house by reason of their filthy condition, and contains no reference to their exposure to or retention of infection.

Section 61 of the above Act authorises a Local Authority to exercise the powers of section 15 of the Infectious Disease (Prevention) Act, 1890, *whether that section has or has not been adopted in the district,* and where the L. A. so determine, those powers may be exercised for providing temporary shelter or house-accommodation with any necessary attendants for any person who leaves a house after any infectious disease has appeared therein ; and when the L. A. has provided such temporary shelter or house-accommodation, they may, on the appearance of any infectious disease in a house, and on the certificate of the M. O. H., cause any person who is not himself sick and who consents to leave the house, or whose parent or guardian (where the person is a child) consents to his leaving the house, to be removed therefrom to such temporary shelter or accommodation, and where consent is not given, under an order of *two* justices, on application of the L. A., subject to any conditions as are imposed by the order. The removal shall be conducted without cost to the person removed or to the parent or guardian of that person. The word " house " is interpreted as in section 47 of the Scottish Act.

Section 15 of the Infectious Disease (Prevention) Act, 1890, reads as follows : —The Local Authority shall from time to time provide, free of charge, temporary shelter or house-accommodation with any necessary attendants for the members of any family in which any infectious disease has appeared, who have been compelled to leave their dwellings for the purpose of enabling such dwellings to be disinfected by the Local Authority.

Section 66 of the Public Health Acts Amendment Act, 1907, is identical in phraseology with section 47 of the Scottish Act in respect of sub-sections 1, 2, 3, and 5, except that in the English Act the word " dangerous " precedes the words " infectious disease " in sub-section 1, and the word " master " has been substituted for the word " occupier " in that sub-section and in sub-sections 2 and 4. The expression " master " is defined to mean the person in occupation of or having the charge, management, or control of a house or part of a house, and where a house is let out in separate tenements, or is a lodging-house wholly let to lodgers, includes the person receiving the rent from such tenants or lodgers.

It will be observed that the meaning attached to the words " house " and " tenement " in the English Act is different from the meaning in the Scottish Act. In Scotland, a *tenement* is usually spoken of as being divided into houses or separate occupancies held by separate occupiers ; in England, and certainly in this section 66, a *house* is spoken of as being let out in separate tenements.

Section 67 of the same Act of 1907 enacts that—the L. A. may provide nurses for patients suffering from any infectious disease in their district, who, owing to want of accommodation at the hospital or danger of infection, cannot be removed to hospital, or in cases where such removal is likely to endanger the patients' health, and may, if they think fit, charge reasonable sums for the services of nurses so provided ; but nothing in this section shall be deemed to take away or diminish the necessity of providing hospital-accommodation for persons suffering from infectious disease.

Section 68 makes it unlawful to hold any wake over the body of any person who has died of infectious disease, and the occupier of any premises to permit any such wake to be so held, or for any person to attend any such wake, under a penalty in each case.]

L. A. may serve notice on owner of bedding, etc., exposed to infection, to deliver same to officer of L. A. for disinfection or destruction.

Section 48. (1) Any Local Authority may serve a notice on the owner of any bedding, clothing, or other articles which have been exposed to the infection of any infectious disease, requiring the delivery of the same to an officer of the Local Authority for the purpose of destruction or disinfection; and if any person fails to comply with such notice he shall be liable to a penalty.

[This is akin in terms to section 6 of the Infectious Disease (Prevention) Act, 1890, and to section 61 of the Public Health (London) Act, 1891.]

(2) Such bedding, etc., if disinfected by the Local Authority, shall be returned to the owner free of charge, and if any of such suffer any unnecessary damage, reasonable compensation shall be paid to the owner.

Persons engaged in washing or mangling clothes to furnish to L. A. a list of customers when required.

Section 49. Whenever it shall be certified to the Local Authority by the M. O. H. that it is desirable, with a view to prevent the spread of infectious disease, that they should be furnished with a list of the customers of any person or company engaged for gain in the washing or mangling of clothes, the Local Authority may require such person or company to furnish to them a full and complete list of the names and addresses of the owners of clothes for whom they have done work during the past six weeks; and such person or company shall provide such a list, for which the Local Authority shall pay the sum of sixpence, and at the rate of sixpence for every twenty-five names contained, but no such payment to exceed three shillings. Every person who wilfully or knowingly offends against this enactment shall be liable to a penalty.

[*Note.*—There is no similar provision in any English Public Health Act.

Section 55 of the English Public Health Acts Amendment Act, 1907, enacts that a person shall not take or send to any public wash-house or laundry, for the purpose of being washed, any bedding, clothing, or other things which he knows to have been exposed to infection, unless they have been disinfected by or to the satisfaction of the Local Authority or their M. O. H. or of a qualified practitioner, or are sent to a laundry with proper precautions for the purpose of disinfection, with notice that they have been exposed to infection.]

Forbids any infected matter to be put into ash-pits.

Section 50. (1) Forbids under a penalty any person to knowingly cast or put, or to cause to be cast or put, into any ash-pit, or otherwise to expose, any matter or article infected by infectious disease.

[This section is akin to section 13 of the Infectious Disease (Prevention) Act, 1890, and section 62 of the Public Health (London) Act, 1891.]

(2) The Local Authority shall cause a notice of the provisions of this section to be served on the occupier of any house in which they are aware that there is a person suffering from an infectious disease.

[This sub-section corresponds in terms to section 14 of the Infectious Disease (Prevention) Act, 1890.]

Penalty on letting houses in which persons have been suffering from infectious disease.

Section 51. (1) Any person who knowingly lets for hire any house or part of a house in which any person has been suffering from any infectious disease, without having the same, and all articles therein liable to retain infection, disinfected to the satisfaction of the Medical Officer as testified by a certificate signed by him, or (as regards the articles) destroyed, shall be liable to a penalty not exceeding £20.

[This section follows the phraseology of section 63 of the Public Health (London) Act, 1891.]

(2) For the purposes of this section, the keeper of an inn or hotel shall be deemed to let for hire part of a house to any person admitted as a guest into such inn or hotel.

Penalty on persons letting houses on hire who make false statements as to recent existence

Section 52. Any person letting for hire, or showing for the purpose of letting for hire, any house or part thereof, who, on being questioned by any person negotiating for hire as to the fact of there being, or within six weeks previously having been, therein any person suffering from any infectious disease, knowingly makes a false answer to such questions, shall be liable to a penalty or to imprisonment.

of infectious disease.

[This section is taken from section 64 of the Public Health (London) Act, 1891.]

Section 53. (1) Where a person ceases to occupy any house or part of a house in which any person has within six weeks previously been suffering from any infectious disease, and either—

Penalty on ceasing to occupy a house without disinfection, or notice to owner, or on making a false answer.

(*a*) fails to have such house, and all articles therein liable to retain infection, disinfected to the satisfaction of the Medical Officer, as testified by his certificate, or such articles destroyed ; or (*b*) fails to give the owner or occupier of the house notice of the previous existence of such disease ; or (*c*) on being questioned by the owner or occupier of, or by any person negotiating for the hire of, such house or part of a house, as to the fact of there having within six weeks previously been therein any person suffering from any infectious disease, knowingly makes a false answer to such question, he shall be liable to a penalty not exceeding £20.

[This section is similar in terms to section 7 of the Infectious Disease (Prevention) Act, 1890, and to section 65 of the Public Health (London) Act, 1891, except that the penalty is only £10.]

(2) The Local Authority shall cause their officers to serve notice of the provisions of this section on the occupier of any house, or part of a house, in which they are aware that there is a person suffering from an infectious disease.

Section 54. A person suffering from any infectious disease, who is without proper lodging or accommodation, or is so lodged that proper precautions cannot be taken for preventing the spread of the disease, or is lodged in a tent, or van, or in a room with others than those necessarily in attendance on such person, or is on board a ship, may, on a certificate signed by the Medical Officer or other legally qualified practitioner, and with the consent of the superintending body of the hospital to which he is to be removed, be removed by order of a Sheriff, magistrate, or justice, on the application and at the cost of the Local Authority of the district wherein such person is found, to any hospital within a convenient distance, and such person may be therein detained so long as he continues in an infected condition ; or the Sheriff, etc., may direct the removal from the room or house occupied by such person of all others not in attendance on him, the Local Authority providing suitable accommodation for such removed persons ;

Removal to Hospital of Infected Persons without proper lodging.

Provided that no such order shall be necessary where the removal is by consent.

(2) The order may be addressed to any constable or officer of the Local Authority as the Sheriff, etc., thinks expedient, any wilful disobedience or obstruction to any such order to be followed by a penalty.

[This follows very closely section 124 of the English Public Health Act, 1875.

Section 60 of the Public Health Acts Amendment Act, 1907, provides that nothing in section 132 of the English Public Health Act, 1875, with respect to the recovery of the cost of maintenance in a hospital, shall require the L. A. to recover the same from a patient who is not a pauper where they are satisfied that the circumstances are such as to justify remission of the debt.

Section 132, referred to, gives power to a L. A. to exact the cost of maintenance in a hospital or temporary place for the reception of the sick, whether belonging to them or not, from any patient who is not a pauper, any time within six months after his discharge therefrom, or from his estate in the event of his dying in such hospital or place.

Section 65 of the above Amendment Act enacts that section 124 of the Public Health Act, 1875, shall apply to all persons suffering from any dangerous infectious disease who are in or upon any premises where they cannot be effectually isolated so as to prevent the spread of the disease.

Section 125 of the English Act, 1875, empowers any L. A. to make regulations (to be approved by the L. G. Board) for removing to hospital, and for keeping there so long as may be necessary, any person suffering from a dangerous infectious disorder who is brought within their district by any ship or boat.]

Detention of infected persons in hospital who, on dismissal, would be without proper lodging.

Section 55. (1) A Sheriff, magistrate, or justice, on being satisfied on the application of a Local Authority that a person suffering from any infectious disease is in a hospital, and, on leaving the hospital, would not be provided with lodging or accommodation in which proper precautions could be taken to prevent the spread of the disease, may direct such person to be detained in hospital at the cost of the Local Authority during the time specified by the Sheriff, etc., who may enlarge the time as often as appears to him necessary for preventing the spread of the disease.

(2) The direction may be executed by any constable, officer of the Local Authority, or officer of the hospital.

[This section is in terms similiar to section 12 of the Infectious Disease (Prevention) Act, 1890, and to section 67 of the Public Health (London) Act, 1891.]

Penalty against infectious person exposing himself in any public place.

Penalty against trafficking in infected articles.

Penalty against waking bodies of persons dead of infectious disease.

Section 56. (1) If any person—

(*a*) while suffering from any infectious disease wilfully exposes himself without proper precautions against spreading such disease in any street, public place, shop, inn, hotel, church, or any place used in common by persons other than members of the family or household to which such infected person belongs ; or (*b*) being in charge of any person so suffering, exposes such sufferer ; or (*c*) knowingly gives, lends, sells, pawns, transmits, removes, or exposes, or permits to be washed or exposed in any wash-house or washing-green which is used in common by persons other than by the family or household to which the infected person belongs, without previous disinfection to the satisfaction of the M. O. H. or of a qualified practitioner, as certified by him in writing, any bedding, clothing, or other articles which have been exposed to infection from any such disease ; or (*d*) wakes or permits to be waked in any house, room, or place over which he has control, the body of any person who had died of any infectious disease ; shall be liable to a penalty not exceeding £5.

(2) Provided that proceedings under this section shall not be taken against persons transmitting with proper precautions any bedding, etc., for the purpose of disinfection.

[This section, with the exception of clause (*d*), is mainly based on section 68 of the Public Health (London) Act, 1891.

Section 126 of the English P. H. Act, 1875, is nearly identical with this section in all its clauses, but in Clause (*a*) any person suffering from any infectious disorder is forbidden to enter any public conveyance without notifying previously the owner or driver thereof.

Section 62 of the Public Health Acts Amendment Act, 1907 (England). amends that part of section 126 of the P. H. Act, 1875, which, as it is enacted therein, reads exactly as in clause (*b*) of the Scottish Act, 1897, by enacting that after the word " sufferer " the words " or causes or permits such sufferer to be exposed " are to be added.]

Penalty against parent or guardian knowingly sending an infected child to school.

Section 57. Every parent or guardian having charge of a child who is or has been suffering from infectious disease, or who resides in any house wherein such disease exists or has existed within three months, who shall knowingly or negligently permit such child to attend school without procuring and producing to the teacher of such school a certificate from the Medical Officer, which he shall grant free of charge, or from a qualified practitioner [that such child has become free from disease and infection, and that the house and infected articles therein have been disinfected to the satisfaction of such medical officer or medical practitioner], shall be liable to a penalty ;

(2) Provided that if a person is not required to send notice in the first instance, but only in default of some other person, he shall not be liable to any penalty if he satisfies the Court that he had reasonable cause to suppose that the notice had been duly sent.

Penalty against a teacher permitting knowingly an infected child to attend school.

Any teacher or person in charge of any school who shall knowingly permit any child to attend such school in contravention of this section, shall be liable to a penalty not exceeding 40s.

[The words within square brackets have been amended by the Public Health (Scotland) Amendment Act, 1907, section 1, by substituting for these the following words, viz.: "that proper precautions against spreading disease or infection have been taken, and that such child may attend school without the risk of infecting others."

With the exception of the proviso, the section as it stands in the Act is taken from sections 12 and 13 of the Glasgow Police Amendment Act, 1890.

Section 57 of the English P. H. Acts Amendment Act, 1907, deals with the same subject, but differs substantially in its terms from section 57 of this Act. Its terms are as follows:—No person being the parent or having the care or charge of a child within the district of the Local Authority who is or has been suffering from infectious disease or has been exposed to infection shall, *after a notice from the Medical Officer that the child is not to be sent to school*, permit such child to attend school without having procured from the Medical Officer a certificate (which shall be granted free of charge upon application) that in his opinion such child may attend without undue risk of communicating such disease to others; under a penalty.

Section 58 of same Act enacts (1) that the principal of a school in which any scholar is suffering from an infectious disease shall, if required by the Local Authority, furnish to them within a reasonable time fixed by them a complete list of the names and addresses of the scholars in or attending school or any specified department thereof other than boarders; (2) the Local Authority shall pay for every such list the sum of sixpence where the number of names is twenty-five or less, and a further sum of sixpence for every other twenty-five names in the list; (3) if the principal fails to comply with any of the provisions of this section, he shall be liable to a penalty for each offence; (4) in this section the expression "the principal" means the person in charge of the school, and includes, where the school is divided into departments and there is no single person at the head of the whole school, as respects each department the head of that department.]

Prohibition against infected persons engaging in trade or business.

Section 58. No person suffering from an infectious disease, or who is living in an infected house, [shall milk any animal, or pick fruit, or shall engage in any occupation connected with food, or] carry on any trade or business in such a manner as to be likely to spread such disease, [and any person who knowing himself to be suffering from any infectious disease] contravenes this section shall be liable to a penalty not exceeding £10.

[This section, as framed, is similar to section 69 of the Public Health (London) Act, 1891, and, so far as milking cows is concerned, is in accordance with Article 9 of the Dairies, Cowsheds, and Milkshops Order, 1885. It is also alike in terms to section 52 of the P. H. Acts Amendment Act, 1907.

The section has been amended by the Public Health (Scotland) Amendment Act, 1907. For the series of words within the first square brackets that Act has substituted the following words, viz.: "shall (*a*), without proper precautions against spreading such disease or infection, milk any animal, or pick fruit, or engage in any occupation connected with food, or shall (*b*)"; and for the words within the second square brackets, the following words: "or infection, and any person who knowingly."]

Prohibition against conveying an infected person in any public conveyance or ship.

Section 59. It shall not be lawful for any owner or person in charge of a public conveyance or ship knowingly to convey therein, or for any person knowingly to place therein, a person suffering from any infectious disease, or for a person so suffering to enter any such conveyance or ship, [and any person contravening any of the foregoing provisions shall be liable to a penalty not exceeding ten pounds; and if] any person so suffering is so conveyed, the owner or person in charge of such conveyance or ship shall, as soon as the fact comes to his knowledge, intimate the same to the Local Authority, and shall cause the conveyance, etc., to be disinfected, and if he fails to do this he shall be liable to a penalty.

Such owner, etc., shall be entitled to recover in a summary manner from the person or guardian of the person so conveyed, a sum of money sufficient to cover any loss and expense incurred.

It shall be the duty of the Local Authority, when required by such owner, etc., to provide for the disinfection of such conveyance, etc., and the Local Authority may do so free of charge.

But nothing in this section shall prevent the removal by railway train or by ship of persons suffering from infectious disease, if they are conveyed within an ambulance-waggon or other proper vehicle provided or approved by the Local Authority.

[The words within square brackets have been amended by section 1 of the Public Health (Scotland) Amendment Act, 1907, by the substitution of the following words, viz.: "unless in every such case as aforesaid proper precautions have been taken against spreading such disease or infection; and any person contravening any of the foregoing provisions shall be liable to a penalty not exceeding ten pounds; and if without such precautions."

With some differences, this section as originally framed is alike to section 70 of the Public Health (London) Act, 1891, and to sections 126 and 127 of the Public Health Act, 1875. This section has been closely followed as to terms by sections 63 and 64 of the Public Health Acts Amendment Act, 1907, both in respect of prohibiting the conveyance of infected persons in public conveyances, and of notice to be given to the Local Authority by the owner or driver of the conveyance to have the same disinfected.]

Inspection of dairies *within* district by M. O. H. in cases of infectious diseases in district arising from milk-supply.

Section 60. (1) If the Medical Officer of any district has evidence that any person in the district is suffering from an infectious disease attributable to milk supplied within the district from any dairy *within* the district, or that the milk from any such dairy is likely to cause any such disease to any person residing in the district, he shall visit such dairy and shall examine the dairy and every person engaged in the service thereof or resident upon the premises, or who may be resident in any premises where any person employed in such dairy may reside, and, if accompanied by a veterinary surgeon approved by the Local Authority, shall examine the animals therein; and the Medical Officer shall forthwith report the results of his examination, accompanied by the report of the veterinary surgeon, if any, to the Local Authority or any committee thereof appointed under section 14 of this Act to deal with such matters.

Procedure in case of a dairy *without* the district from which suspected milk is supplied.

(2) If the Medical Officer has evidence that such disease is attributable to milk from any dairy *without* the district, or that milk from any such dairy is likely to cause such disease, he shall forthwith intimate the same to the Local Authority of the district in which such dairy is situated, and such Local Authority shall be bound forthwith by its Medical Officer to examine the dairy and the persons aforesaid, and by a veterinary surgeon to examine the animals therein, previous notice of the time of such examination having been given to the Local Authority of the first-mentioned district in order that the M. O. H. or any approved veterinary surgeon, if they so desire, may be present at such examination.

And the M. O. H. of the second-mentioned Authority shall forthwith report the results of his examination, accompanied by the report of the veterinary surgeon, if any, to that Local Authority (*i.e.*, the second-mentioned Authority) or any committee of the same appointed under section 14 to deal with such matters.

L. A. to meet, hear reports and evidence, and make an order.

(3) The Local Authority of the district in which the dairy is situated, or any committee appointed for the purpose, shall meet forthwith and consider the reports together with any evidence submitted by parties concerned, and shall either make an order requiring the dairyman to cease supply of milk from the dairy until the order is withdrawn, or resolve that no such order is necessary.

Appeal to County Council not competent.

(4) Where proceedings are taken or any order is made under this section

by the Local Authority of a district other than a burgh, it shall not be competent to appeal against such proceedings or such order to the County Council.

(5) The Local Authority may, if the dairy is *within* the district, require the dairyman not to supply milk either within or without the district, and shall give notice of the fact to the L. A. of any district within which they believe the milk to be supplied from such dairy.

L. A. may require dairyman not to supply milk.

(6) Any such order shall be forthwith withdrawn on the L. A., or the M. O. H. on their behalf, being satisfied that the milk from the dairy is no longer likely to cause infectious disease.

Order to be withdrawn when M. O. H. is satisfied dairy is free from infectious disease.

(7) It shall be open to any L. A. or dairyman aggrieved by any such resolution or order, or withdrawal of order, to appeal summarily to the Sheriff in the district in which the dairy is situated, and the Sheriff may either make an order requiring the dairyman to cease from supplying milk, or may vary or rescind any order made by the L. A., and he may at any time withdraw any order made under this section.

L. A. or dairyman may appeal to Sheriff, who shall make an order.

Pending disposal of any such appeal the order shall remain in force.

(8) If any person refuses to permit the M. O. H. or V. S. of either Local Authority to make examination as hereinbefore provided, or after an order has been made supplies milk in contravention of such order, he shall be liable to a penalty for the offence, and to a further penalty for daily disobedience ;

Penalty for refusing M. O. H. or V. S. to make necessary examination.

(9) Provided that—

(*a*) proceedings in respect of the offence shall be taken before a Sheriff having jurisdiction in the place where the dairy is situated ; and

(*b*) a dairyman shall not be liable to an action for breach of contract if the breach is due to an order under this section.

(10) Nothing in or done under this section shall interfere with the operation or effect of the Contagious Diseases (Animals) Acts, 1878 to 1886, or of any order, licence, or act of the Privy Council or the Board thereunder, or of any regulation, licence, or act of a L. A., made or done under any such order of the Privy Council or the Board, or exempt any dairy, building, or thing, or any person from the provisions of any general Act relating to dairies, milk, or animals.

This section not to interfere with operation of Contagious Diseases (Animals) Acts or Act of Privy Council or Board.

[This section, with several modifications, is modelled on section 4 of the Infectious Disease (Prevention) Act, 1890, and on section 71 of the Public Health (London) Act, 1891.

In the Infectious Disease (Prevention) Act, the M. O. H. is only empowered to inspect a dairy, either within or without his district, if authorised by an order of a justice having jurisdiction in the place where the dairy is situated, and if accompanied by a veterinary surgeon to inspect the animals therein. Where the L. A. make an order requiring the dairyman to cease the supply of milk, they are bound to report the facts to the Sanitary Authority and County Council (if any) of the district in which the dairy is situated, and also to the Local Government Board, where the dairy is *without* their district.

The Contagious Diseases (Animals) Acts, 1878 and 1886, were repealed by the Diseases of Animals Act, 1894, with the exception of section 34 of the Act of 1878, and of section 9 of the Act of 1886. Both of these sections refer to dairies. Section 34 of the Act of 1878 gave powers to the Privy Council to make orders as to registration of cow-keepers, inspection of cows, sanitary conditions of dairies, protection of milk against contamination and infection, and the making of regulations by Local Authorities. In virtue of this power the Privy Council issued the Dairies, Milkshops, and Cowsheds Order of 1885. On the passing into law of the C. D. (Animals) Act, 1886, section 9 transferred the powers of the Privy Council to the Local Government Board ; but the order of 1885 remains, nevertheless, in force, and, indeed, many Local Authorities have made regulations in terms of its provisions. The Dairies, etc., Order of 1885 did not, however, extend to the prohibition of the sale of milk which has become infected ; section 60 is intended to supply that defect. (*Vide* p. 416.)]

Section 61. Whenever it shall be certified to the Local Authority by the

Dairymen to supply information and to provide list of customers.

M. O. H. or other qualified practitioner that the outbreak or spread of infectious disease within the district is, in the opinion of the M. O. H. or medical practitioner, attributable to milk supplied by any dairyman, whether wholesale or retail, or to milk supplied by one or other of several such dairymen, whether wholesale or retail,—

(1) The L. A. may require such dairyman, whether within or without the district, to furnish them within a time to be fixed by them (being not less than twenty-four hours) a full and complete list of the names and addresses of all his customers within the district so far as known to him, and such dairyman shall accordingly furnish such list, and the L. A. shall pay to him for every such list at the rate of sixpence for every twenty-five names contained therein. Every person who shall wilfully or knowingly offend against this enactment shall be liable to a penalty.

Dairymen to produce and exhibit invoices, etc., relative to consignment or purchase of milk.

(2) The L. A. may also require such dairyman to furnish them with a complete list of names and addresses of the farmers, dairymen, or other parties from whom, during a period to be specified, the milk, or any part of the milk which they sell or distribute, was obtained, and, if required, to produce and exhibit to the M. O. H. or other authorised person, all invoices, pass-books, accounts, or contracts, connected with the consignment or purchase of milk, and such dairyman shall furnish such lists and exhibit such invoices, etc., accordingly. Penalty follows any wilful contravention of this section.

(3) In any case where the person liable to any penalty under this section is not resident within the district [of the L. A. calling for the invoices, etc.], such penalty may be sued for before the Sheriff of the county in which such person either lives or carries on business by the Procurator-fiscal.

[This section (sub-section 2) is alike in terms to section 53 of the English P. H. Acts Amendment Act, 1907.

Section 54 of the English P. H. Acts Amendment Act, 1907, enacts that every dairyman supplying milk within the district of the Local Authority from premises whether within or beyond the district shall notify to the M. O. H. all cases of infectious disease among persons engaged in or in connection with his dairy as soon as he becomes aware or has reason to suspect that such infectious disease exists.]

Section 62. A person shall not, without the sanction in writing of the M. O. H., or of a qualified medical practitioner, retain unburied for more than forty-eight hours elsewhere than in a room not used at the time as a dwelling-place, sleeping-place, or workroom, the body of any person who has died of any infectious disease, under a penalty.

[This section is borrowed, with a slight difference in phraseology, from section 8 of the Infectious Disease (Prevention) Act, 1890, and from section 72 of the Public Health (London) Act, 1891. The difference consists in the words "in a public mortuary" being in the English Acts, which thus reads :—" elsewhere than in a public mortuary or in a room," etc.]

Body of person dying of infectious disease in Hospital, etc., to be removed only for burial.

Section 63. (1) If a person dies in a hospital or place of temporary accommodation for the sick from any infectious disease, and the M. O. H. or any qualified medical practitioner certifies that in his opinion it is desirable, in order to prevent the risk of communicating such disease or of spreading infection, that the body be not removed from such hospital or place except for burial forthwith, it shall not be lawful for any person to remove the body except for that purpose ; and the body when taken out of such hospital or place shall be forthwith taken direct to the place of burial, and there buried.

(2) If any person wilfully offends against this section he shall be liable to a penalty.

(3) Nothing in this section shall prevent the removal of a dead body from a hospital to a mortuary, and such mortuary shall, for the purposes of this section, be deemed part of such hospital.

[This section is identical with section 9 of the Infectious Disease (Prevention) Act, 1890, and with section 73 of the Public Health (London) Act, 1891.]

Section 64. If (*a*) a person hires or uses a public conveyance or a conveyance that is let for hire, other than a hearse, for conveying the body of a person who has died from any infectious disease without previously notifying to the owner or driver of the conveyance that such person died from such disease; or (*b*) the owner or driver, immediately on his knowing that such conveyance is being or has been used for conveying such body, does not take all reasonable precautions to prevent the spread of infection, or does not forthwith give intimation to the L. A. and provide for the disinfection of the conveyance to the satisfaction of the L. A.; such person or owner or driver shall be liable to a penalty, and to a further penalty for every day during which the offence continues.

Public conveyance, if used for carrying an infectious body, to be disinfected.

[This section is the same as section 11 of the Infectious Disease (Prevention) Act, 1890, and section 74 of the Public Health (London) Act, 1891.]

Section 65. The L. A. may make bye-laws for securing the cleanliness and sanitary condition of public conveyances plying within its district, and for preventing overcrowding in such conveyances.

Power to L. A. to make bye-laws for public conveyances.

Sections 67 to 69 inclusive deal with the Conveyance of Infected Persons to Hospital, Provision of Mortuaries, the Power of a Sheriff or Magistrate to order Removal of Infective Dead bodies to a Mortuary, and the Transportation of Infective Dead Bodies by Railway or other Public Conveyance.

Section 67. L. A. may provide and maintain, or may combine with other Local Authorities so to provide, carriages suitable for the conveyance of persons suffering from any infectious disease, and pay the expense of conveying therein any person so suffering to a hospital or other place of destination.

L. A. may provide means of conveyance for infected persons.

[*Note.*—This section is similar to s. 123 of the English Public Health Act, 1875, and to s. 78 of the P. H. (London) Act, 1891.

Infective persons may be conveyed in ambulances by railway or ship, in terms of s. 59 of the Scottish P. H. Act, 1897, and particularly of the proviso at the end of that section (*vide* p. 476).]

Section 68. L. A. may provide and fit up a proper place or places for the reception of dead bodies before interment (in this Act called a mortuary), and may make bye-laws with respect to the management and charges for the use of the same.

L. A. may provide mortuaries.

[*Note.*—The Burial Grounds (Scotland) Act, 1855, gives power to Parish Councils, or to Town Councils in Parliamentary Burghs, to provide mortuaries, the Secretary for Scotland to make regulations with regard thereto for the protection of the public health and maintenance of public decency.

The English L. G. Board in their Report for 1883, App. p. 15, have laid down model bye-laws for mortuaries, and issued a memorandum with suggestions as to site, construction, and management of the same, with a plan.]

Section 69. (1) Where either (*a*) the body of a person who has died of any infectious disease is retained in a room in which persons live or sleep; or (*b*) the body of such a person is retained without the sanction in writing of the M. O. H., or any legally qualified medical practitioner, for more than 48 hours, elsewhere than in a room not used at the time as a dwelling-place, sleeping-place, or work-room; or (*c*) any dead body is retained in any house or room or ship under circumstances which, if continued, may endanger the health of the inmates thereof, or of any adjoining or neighbouring house or building; or (*d*) any dead body found within the district is unclaimed, or no sufficient person undertakes to bury it, a Sheriff, magistrate, or justice may, on a certificate signed by a medical officer or other legally qualified medical practitioner, direct that the body be removed, at the cost of the L. A., to any available mortuary, and be buried within the time limited by the Sheriff, etc.; and if it is the body of a person who has died of an infectious disease, or if he considers immediate burial necessary, the Sheriff, etc.,

Power of Sheriff, etc., to order removal of dead body to a mortuary.

may direct that the body be buried immediately without removal to the mortuary.

(2) Unless the friends or relations of the deceased undertake to bury, and do bury, the body within the time limited, it shall be the duty of the L. A. to bury such body, and any expense so incurred may be recovered by them summarily from any person legally liable to pay the expenses of such burial.

(3) It shall not be lawful to transport the body of any person who has died of any infectious disease by railway or other public conveyance, not being a conveyance reserved for such purpose, unless and until the Medical Officer, or other legally qualified medical practitioner, has certified that every precaution necessary for the public safety has been adopted to his satisfaction, and any undertaker or other person who, without such certificate, shall knowingly remove or assist in removing, and any person who shall procure or endeavour to procure the removal of such dead body without having obtained such certificate, shall be liable to a penalty.

(4) If any person obstructs the execution of any direction given by a Sheriff, etc., under this section, he shall be liable to a penalty not exceeding five pounds.

[*Note.*—This section, with the exception of the sub-head (*d*) (1), is founded on s. 91 of the P. H. (London) Act, 1891. While the sub-heads (*a*) and (*b*) refer to infective bodies, sub-heads (*c*) and (*d*) refer to *any* dead bodies.

It would appear that the only duty of the L. A. under this section is to bury: if the police for police purposes think it necessary to keep a body unburied, they must take the body and keep it in their own custody and at their own expense, the L. A. burying the body when it is no longer required for police purposes. See also section 63 (3), p. 478.]

To the foregoing sections there should also be added, perhaps, sections 70 and 71, which deal with the Provision of Places for Post-Mortem Examination of Bodies.

L. A. may provide a place for p.-m. examination of bodies.

Section 70. (1) Empowers a L. A. to provide and maintain a proper building (otherwise than a poorhouse) for the reception of dead bodies during the time required to conduct any post-mortem examination ordered by a lawful authority, and may make regulations with respect to the management of such building.

(2) Any such building may be provided in connection with a mortuary, but this enactment shall not authorise the conducting of any post-mortem examination in a mortuary.

[*Note.*—This section corresponds to s. 143 of the English Public Health Act. 1875, and to s. 90 of the P. H. (London) Act, 1891.]

Empowers Local Authorities to combine for providing mortuary, etc.

Section 71. Empowers Local Authorities, with approval of the L. G. Board, to combine with respect to establishment of mortuaries and buildings for post-mortem examinations, or by contracting for the use by one of the contracting authorities of any such place provided by another of such contracting authorities upon such terms as may be agreed upon.

[*Note.*—This section is taken from s. 91 of the P. H. (London) Act, 1891.]

The Public Health (Scotland) Amendment Act, 1907.

This Act was passed to amend sections 57, 58, and 59 of the Act of 1897.

Section 1. (1) Enacts that section 57 of the P. H. (Scotland) Act, 1897, shall be read as if the words "that proper precautions against spreading disease or infection have been taken, and that such child may attend school without the risk of infecting others" were substituted for the words "that such child has become free from disease and infection, and that the house and everything therein exposed to infection has been disinfected to the satisfaction of such Medical Officer or medical practitioner."

(2) Section 58 of the said Act shall be read as if the words "shall (*a*), without proper precautions against spreading such disease or infection, milk any animal,

or pick fruit, or engage in any occupation connected with food, or shall (*b*)" were substituted for the words "shall milk any animal, or pick fruit, or shall engage in any occupation connected with food, or"; and as if the words "or infection, and any person who knowingly" were substituted for the words "and any person who knowing himself to be suffering from any infectious disease."

(3) Section 59 of the said Act shall be read as if the words "unless in every such case as aforesaid proper precautions have been taken against spreading such disease or infection; and any person contravening any of the foregoing provisions shall be liable to a penalty not exceeding ten pounds; and if without such precautions" were substituted for the words "and any person contravening any of the foregoing provisions shall be liable to a penalty not exceeding ten pounds; and if."

Section 2. This Act shall apply to Scotland only.

[The only other provision in the Public Health Acts Amendment Act, 1907, which is not made in any other Act, English or Scottish, is that made in section 59, which is as follows:—

Section 59. (1) If any person knows that he is suffering from an infectious disease, he shall not take any book or use or cause any book to be taken for his use from any public or circulating library.

(2) A person shall not permit any book which has been taken from a public or circulating library, and is under his control, to be used by any infectious person.

(3) A person shall not return to any such library any book which he knows has been exposed to infection from any infectious disease, or permit any such book to be so returned, but shall give notice to the L. A. that the book has been so exposed, and the L. A. shall cause the book to be disinfected and returned to the library, or to be destroyed.

(4) The L. A. shall pay to the proprietor of the library from which the book was procured the value of any book destroyed under this section.

(5) If any person contravenes the terms of this section, he shall be liable to a penalty.]

P. H. (Scot.) Act, 1897; PART IV

PREVENTION OF EPIDEMIC DISEASE

Section 78. The Board may from time to time make, alter, and revoke such regulations as to the said Board may seem fit, with a view to the treatment of persons affected with any epidemic, endemic, or infectious disease, and preventing the spread of such diseases, as well on the seas, rivers, and waters of Scotland, and on the high seas within three miles of the coast thereof, as on land; and may declare by what authority or authorities such regulations shall be enforced and executed.

General Power of L. G. Board to make Regulations regarding epidemic diseases.

[This section is identical with section 130 of the English Public Health Act, 1875, except that the words "cholera or" are additional after the words "affected with."]

Section 79. Whenever any part of Scotland appears to be threatened with or is affected by any formidable epidemic, endemic, or infectious disease, the Board may make and from time to time alter and revoke regulations for all or any of the following purposes; namely—

Power of L. G. Board to make, etc., Regulations for various purposes in formidable epidemics.

(1) For the speedy interment of the dead;

(2) For house-to-house visitation;

(3) For the provision of medical aid, dispensing of medicine, and accommodation, for the promotion of cleansing, ventilation, and disinfection, and for guarding against the spread of disease;

(4) For any such matters or things as may to them appear advisable for preventing or mitigating such disease;

and may by order declare all or any of the regulations so made to be enforced within the whole or any part or parts of the district of any L. A., and to apply to any ships, whether in ports or on inland waters or on arms or parts of the sea within the jurisdiction of the Admiralty, for the period in such order mentioned; and may by any subsequent order abridge or extend such period.

[This section is, *pari passu*, alike to section 134 of the English Public Health Act, 1875, with the exception of sub-section 4 of this section, which is not included.]

Section 80. Enacts that all regulations and orders of the L. G. Board in pursuance of this part of this Act shall be published in *The Edinburgh Gazette.*

[It is alike to section 135 of the English Public Health Act, 1875, with the difference that any such regulations, etc., shall be published in *The London Gazette.*

The Epidemic and Other Diseases Prevention Act, 1883, practically re-enacts what is contained in ss. 134 and 135 of the P. H. Act, 1875, and extends the same provisions to Ireland, and amends s. 150 of the P. H. (Ireland) Act, 1878, by empowering the Irish Local Government Board to direct urban Sanitary Authorities to carry out the regulations when in force in their districts.]

L. A. to see to execution of Regulations of L. G. Board.

Section 81. Declares that the L. A. of any district within which regulations so issued by the L. G. Board are declared to be in force shall superintend and execute the same.

[This corresponds to section 136 of the English Act, 1875.]

Power of entry to officers of Local Authority.

Section 82. The L. A. and their officers shall have power of entry on any premises for the purpose of executing or superintending the execution of any regulations so issued by the L. G. Board as aforesaid.

[This corresponds to section 137 of the English Act, 1875.]

L. G. Board may combine Local Authorities.

Section 83. The L. G. Board may, if they think fit, by order authorise or require any two or more Local Authorities to act together for the purposes of this part of this Act.

[This corresponds to section 139 of the English Act, 1875.]

When Regulation in force, overcrowded houses to come under provisions for common lodging-houses.

Section 84. When any such regulation so issued by the Board is in force in any place, on the certificate of a M. O. H., or of two qualified medical practitioners, or on report of a sanitary inspector or other sufficient evidence, that any house or part of a house is so overcrowded as to be dangerous to health, the L. A. shall have power to regulate the same according to the provisions of this Act in reference to common lodging-houses.

Enforcement of Regulations by Government officers, etc.

Section 85. Regulations of the Board made in pursuance of this part of this Act may provide for such being enforced and executed by officers of Customs and officers and men employed in the Coastguard as well as by other authorities and officers, and may provide for—

(*a*) the signals to be hoisted by vessels having any case of epidemic, endemic, or infectious disease on board; and

(*b*) the questions to be answered by masters, pilots, and others on board any vessel as to cases of such disease on board during the voyage or on arrival of vessel; and

(*c*) the detention of vessels and of persons on board vessels; and

(*d*) the duties to be performed in cases of such disease by masters, pilots, and other persons on board vessels.

[This section is taken from section 1 of the Public Health Act, 1896, which, so far as it relates to Scotland, is repealed by this Act.]

Section 86. Enacts that in making regulations referred to in this part of this Act regard shall be had to the expediency of uniform regulations throughout the whole of the United Kingdom.

Section 87. Deals with penalties for neglect to carry out, refusal to obey, or obstruction in the execution of, any regulation made under this Part of this Act.

CLEANSING OF PERSONS

The law on this subject is contained in the following Acts :—

1. **Cleansing of Persons Act, 1897.**
2. **Children Act, 1908;** Section 122.
3. **Education (Scotland) Act, 1908;** Section 6.

I. Cleansing of Persons Act, 1897. Applicable to United Kingdom.

Section 1. Any Local Authority shall have the power, when they see fit, to permit any person who shall apply to them on the ground that he is infested with vermin, to have the use, free of charge, of the apparatus (if any) which they possess for cleansing his person and his clothing from vermin. The use of such apparatus shall not be considered as parochial relief or charitable allowance to the person using the same, or to the parent of such person, and no such person or parent shall by reason thereof be deprived of any right or privilege or be subject to any disqualification or disability. Local Authorities may expend any reasonable sum on buildings, appliances, and attendants required for carrying out the terms of this Act, such expenses to be defrayed out of any rate or fund applicable by them for general sanitary purposes or for poor relief.

Section 2. "Local Authority" means in England the council of any county borough, the district council of any district, any board of guardians, and in the county of London any Sanitary Authority as defined in the P. H. (London) Act, 1891.

Section 3. In Scotland the term "Local Authority" means and includes any L. A. under the P. H. (Scot.) Act, 1867, and any Act amending the same; but such L. A. shall not erect buildings for the purposes of section 1, except with the sanction of the L. G. Board for Scotland.

Section 4. Applies *pari passu* to Ireland.

II. Children Act, 1908. Applicable to United Kingdom.

Section 122. (1) A Local Education Authority may direct their medical officer or any person provided with and, if required, exhibiting the authority in writing of their medical officer, to examine in any public elementary school provided or maintained by the Authority the person and clothing of any child attending the school, and if, on examination, the medical officer, or any such authorised person as aforesaid, is of opinion that the person or clothing of any such child is infected with vermin or is in a foul or filthy condition, the Local Education Authority may give notice in writing to the parent or guardian of, or other person liable to maintain, the child, requiring him to cleanse properly the person and clothing of the child within 24 hours after receipt of the notice.

(2) If such person fails to comply with the terms of the notice within such 24 hours, the medical officer, or some person provided with and, if required, exhibiting the authority in writing of the medical officer, may remove the child referred to from any such school, and may cause the person and the clothing of the child to be properly cleansed in suitable premises and with suitable appliances, and may, if necessary for that purpose, without any warrant other than this section, convey to such premises and there detain the child until the cleansing is effected.

(3) Where the Sanitary Authority within the district of a Local Education Authority have provided, or are entitled to the use of, any premises or appliances for cleansing the person or clothing of persons infected with vermin, the S. A. shall, if so required by the Local Education Authority, allow the Local Education Authority to use the same upon such payment as may be agreed between them, or, failing agreement, settled by the L. G. Board.

(4) Should a parent or guardian of, or other person liable to maintain, the child allow such child after such cleansing again to get into a condition so that

it is again necessary to proceed under this section, such parent, etc., shall be liable to a fine not exceeding 10s.

(5) Where a Local Education Authority give notice under this section to any parent, etc., requiring him so to cleanse the person and clothing of any such child, the Authority shall also furnish the parent with written instructions describing the manner in which the cleansing may be best effected.

(6) The examination and cleansing of girls under this section shall only be effected by a duly qualified medical practitioner or by a woman duly authorised by the medical officer.

(7) " Medical officer " here means any officer appointed for the purpose of s. 13 of the Education (Administrative Provisions) Act, 1907.

III. Education (Scotland) Act, 1908.

Section 6. (1) When as the result of medical inspection or otherwise it is brought to the notice of a School Board that a child attending a school within their district is in a filthy or verminous state, . . . it shall be the duty of the School Board, after due warning, to summon either or both of the parents or the guardian of such child to appear before them to give an explanation of the child's condition, and, if such explanation is not forthcoming or is insufficient or unsatisfactory, the Board shall send to the parent or parents, etc., of the child, and to the Procurator-fiscal, a copy of such finding, and it shall be the duty of the Procurator-fiscal to institute a prosecution under the following sub-section.

(2) Neglect to exercise due care of a child as aforesaid shall be deemed wilful neglect likely to cause the child unnecessary suffering within the meaning of the Prevention of Cruelty to Children Act, 1904, or any Act amending the same, and shall be punishable summarily as an offence of cruelty in terms of such Act ; provided that if the School Board, or in the event of a prosecution the Sheriff, be satisfied that owing to poverty or ill-health the parents., etc., are unable to give the child the necessary personal attention, the School Board, if satisfied that the necessities of the case will not be provided for by voluntary agency, shall make such provision for the child out of the school fund as they deem necessary, such provision not to deprive such parent, etc., of any franchise, right, or privilege, or to subject him to any disability ; and the School Board shall have power in such case to make temporary provision for the child out of the school fund pending the completion of the procedure prescribed, and to recover the cost of the same from the parent, etc., unless in the case of poverty or ill-health of the parent and his inability to give the child the necessary personal attention.

CHAPTER XV

ISOLATION HOSPITALS

By section 66 of the Public Health (Scotland) Act, 1897, any Local Authority may, and if required by the Board shall, provide, furnish, and maintain for the use of inhabitants of their district suffering from infectious disease, hospitals temporary or permanent. The English Act of 1875, sec. 131, makes the duty optional. By section 3, Isolation Hospitals Act, 1893—Lord Thring's Act—and the Isolation Hospitals Amendment Act, 1901, a County Council may provide or cause to be provided in any district within their county an isolation hospital or hospitals for the reception of patients suffering from infectious diseases. As alternatives to building such hospitals, the Public Health Acts of both countries provide that a Local Authority may contract for the use of any such hospital or part thereof, may enter into any agreement with any person having the management of any such hospital or part thereof, on payments to be agreed upon, or may, in place of providing such hospitals, employ nurses to attend infected persons in their own homes, and also supply medicines and medical attendance for such persons.

Experience has abundantly demonstrated not only that without such hospitals no Local Authority can adequately cope with the repression of infective diseases, but that their institution has proved of the highest value.

The points to be considered in the establishment of an isolation hospital, when its erection has been determined, are briefly these—viz. (1) size; (2) situation and site; (3) incidence of accommodation in respect of sex and diseases.

I. Size.—As a general proposition it may be held that hospitals should be of such a size as will provide at least one bed per thousand of population. But this ratio may be increased or diminished in the light of the capacity of a population to afford means of efficient home-isolation. It may be laid down as a general rule that in mixed populations chiefly composed of the working-class the ratio should be higher than the foregoing, and in well-to-do populations it may probably be somewhat lower. Glasgow, for example, for a population of 800,000 (in round numbers), has provided 950 beds. This ratio, however, is more difficult to determine in rural than in urban districts, and in the former especially, where the population is widely scattered. In county districts, the ratio must be determined by the above factors in the local problem, and the number of hospitals and the places where they are to be planted must be determined largely by the distances to be traversed by the patients removed. Hitherto, this has been met during panic, and in face of marked outbreaks of disease, by the erection of temporary wooden structures, most of which, however, are unsuitable, and never can be of the utility of more substantial buildings. While isolation hospitals are intended for infectious diseases, experience has demonstrated the peril of treating smallpox cases alongside those of other infective diseases. Consequently it works out in practice that a special

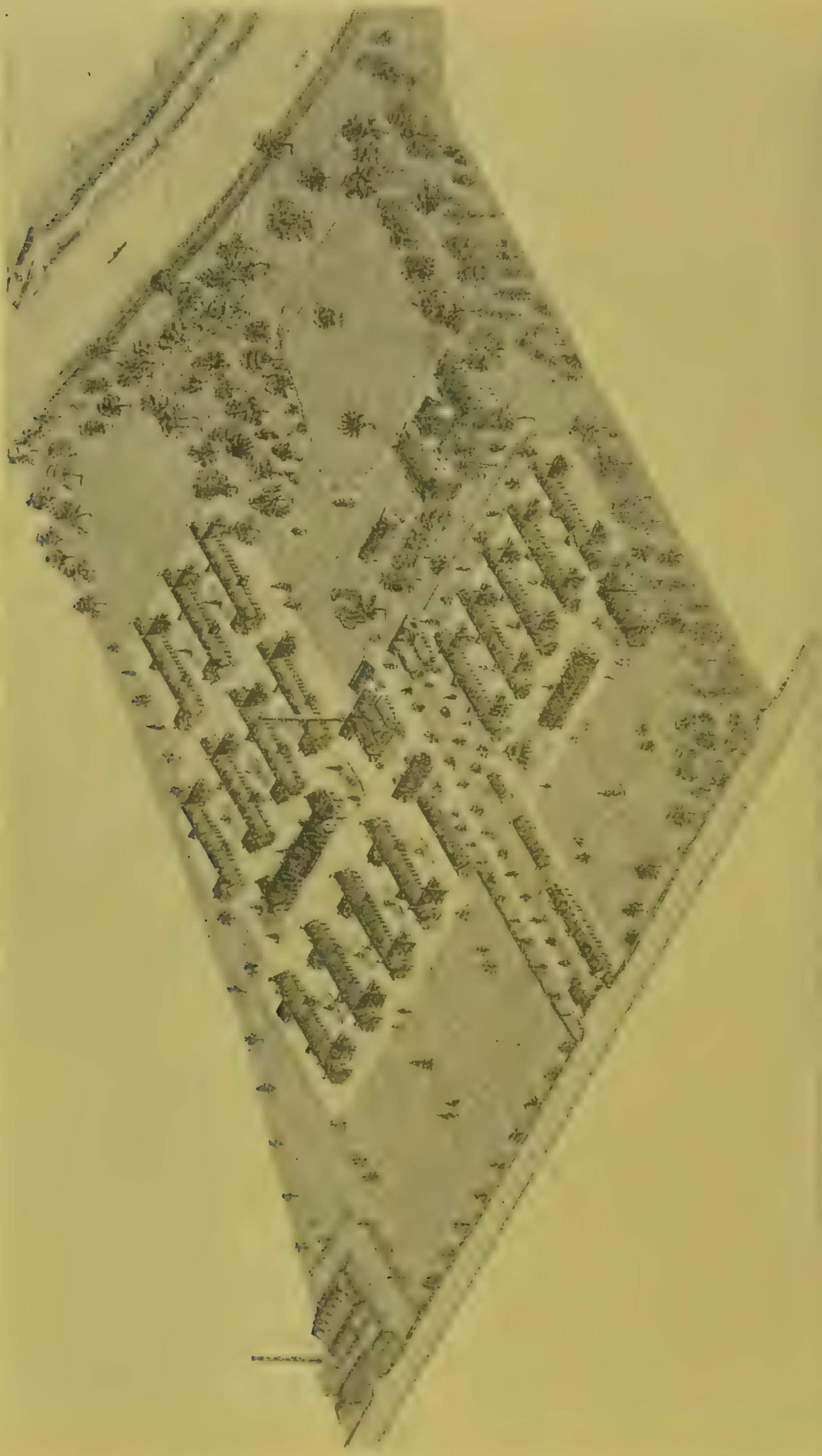

FIG. 120.—This figure shows the distribution of the buildings. At the main gateway is the Inquiry Office. On the right of the main entrance-way is the Smallpox Hospital, which is separated from the other parts of the Hospital by a high wall, and which has a separate entrance, shown among the trees in the lower corner of the figure. The Administrative Block is between the Smallpox Hospital and the river Clyde. On the left of the main entrance-way are the Fever Blocks. At the upper left corner is the Disinfection and Laundry Department.

hospital for this disease must be provided, in addition to the ordinary isolation hospital. In these days smallpox is a more likely disease in a populous place than in a rural neighbourhood, but occasional serious recrudescences of the disease point to the need for the provision of accommodation against its possible outbreak even in rural communities. In view, however, of its infrequency in such neighbourhoods, it would be too much to demand of county Local Authorities that they should build, furnish, and equip a permanent hospital to be devoted solely to the treatment of smallpox, but it would be reasonable to ask that such Local Authorities should provide their districts with portable hospitals and with prepared sites, so that hospital accommodation for this disease could be instituted within twenty-four hours. Recent improvements in the construction of portable hospitals in fitting parts enables this to be rapidly and efficiently done, and with every prospect of comfort to inmates.

II. Situation and Site.—To serve the needs of a populous community and in order to minimise the risks of removal, an isolation hospital should be situated within comparatively easy reach of the centre of population whose needs it is to supply, and yet ought to be sufficiently removed to overcome reasonable objections, such as nearness to inhabited houses and possible risks of infection to the occupants thereof. No Local Authority is entitled to plant a hospital in such a position as will prove a nuisance either in common law or in public health law, or will produce injury to the rights of the owners of adjoining property by causing a nuisance. Lord Blackburn laid down the rule of law on this point in an English appeal case—Metropolitan Asylum District *v.* Hill [1] :—" To put together," he said, " in one spot patients suffering from infectious disease is lawful, but it must be made under such guards as not to endanger the public health by communicating this infectious disease ; and, as it seems to me, so as not to produce injury to the rights of owners of adjoining property by producing a nuisance to it." The outskirts of a city, therefore, are indicated generally as the situations which ought to be chosen for erection of a hospital, since there is the greater likelihood of securing a more open site, and, consequently, unconfined air-space. The propinquity of an isolation hospital to dwelling-houses, or of wards for infective diseases to non-infected persons in ordinary wards in a hospital, has been proved to be prejudicial to the inhabitants or occupants. The late Sir Richard Thorne Thorne demonstrated this in the case of the Children's Hospital at Pendlebury—an excellent modern hospital—in which the main hospital is devoted to the treatment of the ordinary diseases of childhood, and a separate pavilion to the treatment of infective diseases. He showed that children in the ordinary wards contracted diseases apparently from the infective pavilion. The truth of this fact has been probably more clearly demonstrated, however, with respect to smallpox. In Power's report upon the incidence of smallpox in the vicinity of Fulham Hospital, he pointed out that the disease was evidently transmitted by the medium of the atmosphere to occupants of houses situated some distance from the Hospital, that the incidence in number of cases diminished directly as the distance,

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[1] 6 App. Cas., 193 ; 44 *Law Times* (N.S.), p. 653.

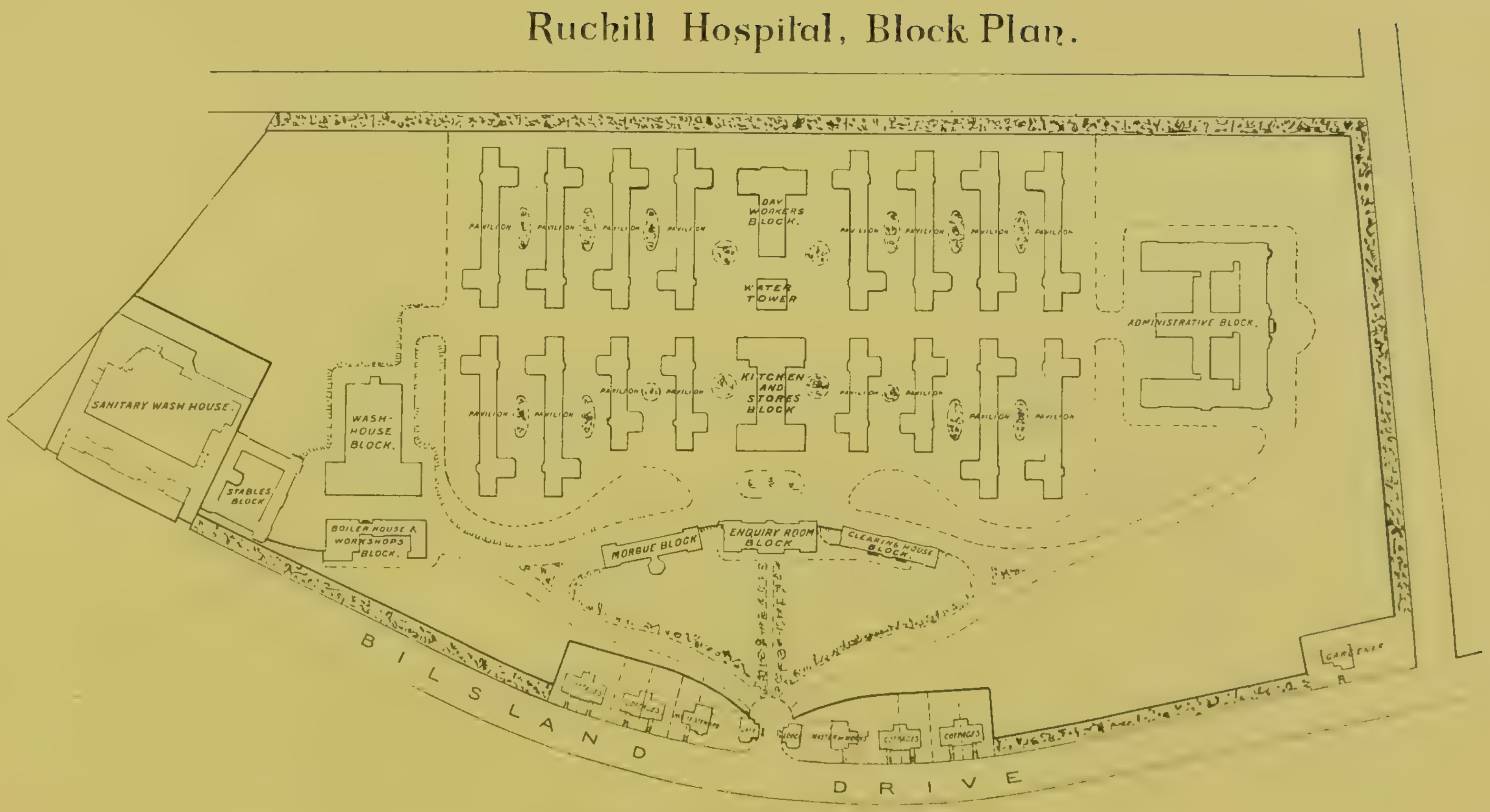

FIG. 121.—The illustration is self-explanatory.

and that the convection of the disease could not be attributed to lines of traffic. In respect of the hospital at Sheffield, Barry found a like incidence of disease, but the element of the possibility of personal convection could not be eliminated from the problem. Doubt has been cast by different writers concerning the absolute proof in these and other instances of the aerial convection of the disease; the facts point, however, to carefulness in choice of site. Accepting that view, the English Local Government Board have advised that a Local Authority should not contemplate the erection of a smallpox hospital on any site where, within a quarter of a mile of it as a centre, there exists any hospital, work-house, large school, or other establishment, or a population of 150 to 200 persons, or on any site where within half a mile of it as a centre there exists a population of 500 to 600 persons, whether in institutions or in dwelling-houses. To avoid any risk of aerial transmission of infection, both English and Scottish Local Government Boards demand that no building which is a constituent part of an ordinary isolation hospital shall be nearer than *forty* feet to the boundary-wall, and that each block should be separated from the others by a like distance; and further, that said boundary-wall should not be less than 6½ feet in height. In respect to smallpox a larger separating zone is necessary—viz. from 120 to 150 feet.

The site chosen, while to some extent dependent upon local circumstances, ought to combine as far as possible the following conditions—viz. (1) a porous subsoil; (2) a gentle sloping ground-surface; and (3) an exposure protected from the east and north, and open to the south and west. Such conditions, accompanying abundance of good water and pure air, will go far to contribute to the healthiness of the hospital.

The area of the site ought to bear a direct relation to the proposed number of beds. The Local Government Board of England in this respect suggests eight beds per acre. Hitherto this has been seldom realised. The maximum, however, ought not to exceed twenty beds per acre. If a few well-known hospitals be taken at random, it will be found that the Belvidere Hospital has thirteen beds, and Ruchill Hospital (both of Glasgow), twelve beds; that at Heathcote, Leamington, eleven beds; Ealing, twelve beds; Sheffield, forty-eight beds; Dunfermline, fourteen and a half beds; Willesden, six beds; and Bristol, (at present) about four beds per acre.

III. Incidence of Accommodation.—In rural hospitals, facilities must be provided for the treatment of at least three different diseases at the same time; in urban communities, the facilities must be extended much beyond this. In respect of the latter indeed, provision must be made for the reception and separation of each of the diseases scheduled in the Notification Act, for although the whole of these diseases may not be coexistent, it generally happens that there is an excess of cases from one or more of the infective diseases sufficient to occupy the spare space. The accommodation must be duplicated for the sexes. The total number of beds to be provided will be regulated by the number of population for the needs of which the hospital is to be erected.

In terms of the Public Health (Scotland) Act, 1897, section 66, sub-section 3 (*vide* p. 509), the Scottish Local Government Board have issued a memorandum as to site and plans of hospitals for infectious diseases, of date 31st

August 1899, wherein the following rules are laid down for the purpose of facilitating the consideration by the Board of applications for their approval of the site and plans for the construction of such hospitals :—

The application should be accompanied by the following in respect of—

I. Site: (*a*) An ordnance survey sheet with proposed site delineated preferably in red colour ; (*b*) a statement of dimensions of site—length, breadth, and area ; (*c*) a statement of number of beds—the unit space being 2000 cubic feet per adult patient and their ward-distribution ; (*d*) a general description of site with information as to (1) soil and sub-soil, (2) exposure, (3) drainage facilities, (4) water-supply, (5) accessibility, (6) distance from furthest points of district to be served, (7) distance from nearest inhabited houses, (8) distance from nearest medical practitioner where it is not proposed to have a resident practitioner, and in rural districts, (9) distance from nearest railway-station, and (10) distance from chief populous centres in district to be served ; (*e*) a statement from the Medical Officer of Health of district, or in the case of proposed combination hospital, from the Medical Officers jointly, expressing opinion of the site.

II. Buildings: Plans consisting of (*A*) Block plan on a scale of $\frac{1}{32}$nd inch to 1 foot, which shows (1) extent of site, with note of acreage, the boundaries to be edged of light green colour ; (2) the buildings outlined in position and coloured all over, the ward blocks in red, the others in light brown, each block to be named and numbered relative to the detail plans, with distances from each other and from boundaries in figures ; (3) public roads, accesses, and surroundings, with the nature of these noted, and any buildings within 50 yards of the site indicated ; (4) lines of drainage, giving diameters of drains and position of traps, ventilators, and all other openings distinctly marked, nature of outfall, method of treating sewage before leaving premises, and any works connected therewith. If a separate system of drainage is proposed for rain-water and for sewage, the lines of both must be shown.

(*B*) **Plans, Sections, and Elevations** in detail of each block of building, on a scale of one-eighth of an inch to the foot, sufficient to illustrate fully the design in parts, general structure, and in details : the Plans are to be figured with the linear sizes of the apartments, the wards and bedrooms to show the position of each bed, and the total cubic contents and floor-area of each apartment to be given in figures : the Sections are to give the height inside to the top of the wall, and, when roof is an open roof, the height also to the ridge of the roof ; and the Elevations are to show any levelling of ground required.

(*C*) A sufficient boundary-wall or continuous fence to be included.

(*D*) Heating and ventilating arrangements to be shown in such detail as may be necessary to explain system or systems proposed.

These plans should be accompanied by (*E*) a general description, explaining heating and ventilation arrangements in detail, also the number of patients, and the number and description of the resident officials, for whom provision has been made, and by (*F*) a statement by the Medical Officer, or Officers where a combination hospital is proposed, of Health of the district, in which an opinion is expressed regarding the plans and any points stated to which objection is taken.

An isolation hospital of any pretensions ought to include the following different buildings suitable for their different uses—viz.

1. An administrative block for hospital staff, dispensary, stores, etc. ;
2. Wards for the treatment of different diseases during acute illness and during convalescence, for the separation of the sexes, and for probation of doubtful and separation of non-infective cases ;
3. Accessory buildings, which should include laundry, wash-house, disinfecting apparatus, stables, heating apparatus, mortuary, offices, and inquiry-room. (*Vide* Figs. 120–121.)

1. *The Administrative Department.*—Little need be said on this point, except that this department should provide commodious space for resident physicians, nurses, and others on the resident staff, and that it should occupy a central or convenient position relative to the different working parts of the hospital. It will depend upon the amount of work to be done and upon the importance of the hospital, whether or not operating theatres should also be provided, and, in addition, a bacteriological laboratory for research, verification of diagnosis, and the study of the effects of serum treatment. In view of the importance of the bacteriological diagnosis of doubtful throat cases, of infective pneumonia, and of blood-reactions in enteric fever and other diseases, every well-equipped isolation hospital should possess such a laboratory.

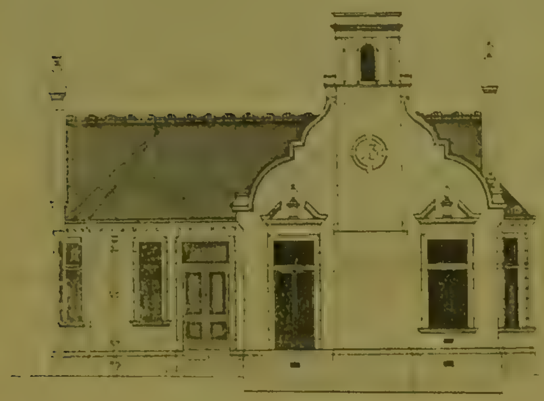
FIG. 122.—End Elevation Plan of a Ward, Ruchill Hospital, Glasgow.

2. *Wards.*—Isolation hospitals are now most commonly built of the *pavilion type* and of one storey in height. This system of planning was first advocated by Tollet, a French architect, about the middle of last century. When viewed from every point, such a type of hospital is probably the best. The chief objection to it consists in the large area of land required for its setting, a desideratum which is sometimes most difficult to obtain at any cost, and, always, even if obtainable, at enhanced cost, in the neighbourhood of populous places. From time to time the question has been raised, whether or not it is quite possible to construct an efficient isolation hospital on other than the pavilion type. Obviously, if an affirmative answer were forthcoming, much trouble and expense would be saved to urban Local Authorities. The answer to this

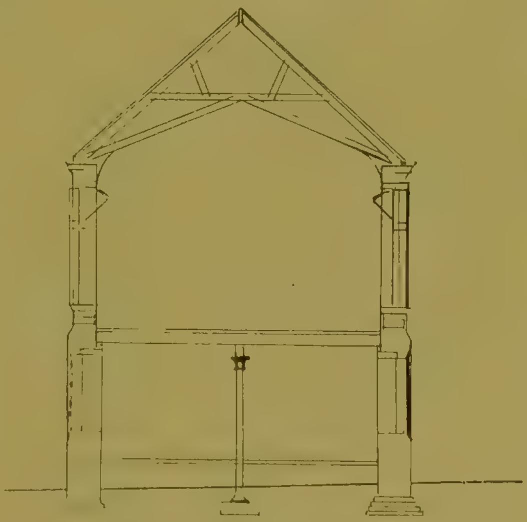
FIG. 123.—Cross Section of Ward in Ruchill Hospital.

question depends upon a variety of factors, chief of which are probably the following—viz. likelihood of convection of contagium from one ward to another, conditions of light and ventilation, service, and administration. It is necessary, therefore, to discuss the merits and demerits of types of hospital-construction.

The advantages of the pavilion type are: (1) that each unit is separated from the rest, and even where there is an existing corridor, opposite windows therein permit of cross ventilation; (2) that each ward or unit is lighted from both sides, and therefore may also be ventilated by cross ventilation; (3) where the wards have been properly planned, the maximum amount of sunshine may be obtained; (4) patients can be more easily classified and sorted out; and (5) the administration is easy, as there are no stairs to climb and no long corridors, although against that must be put the distance to be covered by the staff from the administrative block. Thus are secured good ventilation, maximum sunlight, classification of patients, and the minimum of trouble in administration. The main and perhaps the only objection which may be urged against their use is their great initial cost with relation to the number of patients treated. While eight beds per acre is the ideal of the English Local Government Board, no harm can ensue if the number of beds is at least double or more than double that figure, provided that efficient ventilation and other factors prevail. It has with much reason been urged that the pavilion type may be adopted,

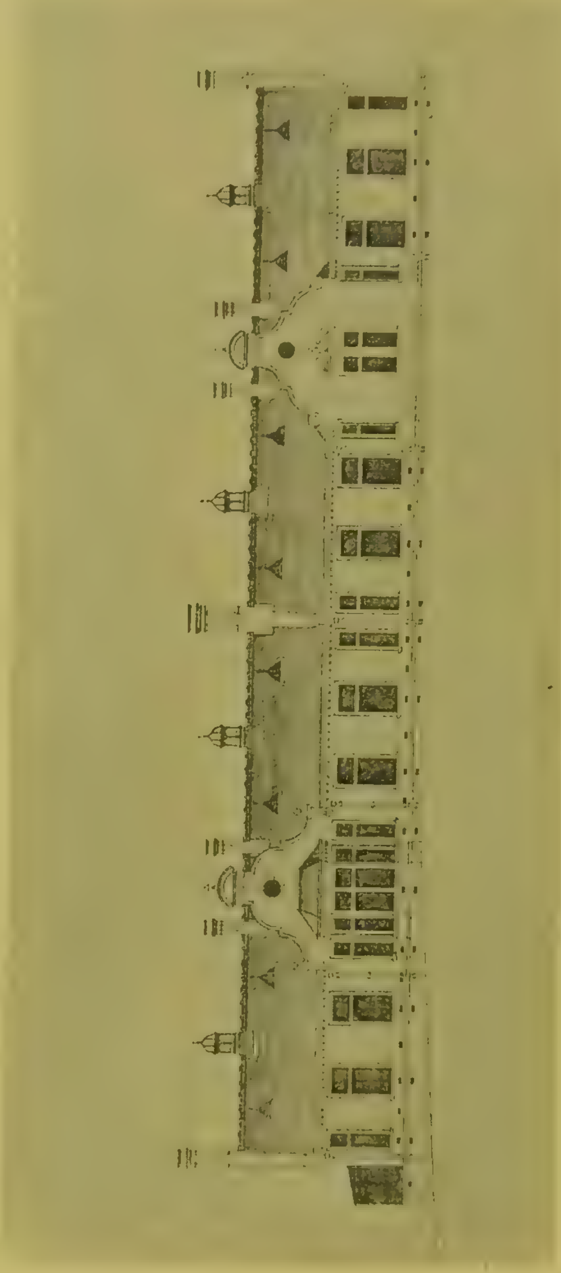

FIG. 124.—Elevation Plan of a Large Ward in Ruchill Hospital.

but that the building should be of more than one storey. To this it has been objected that administration is difficult; but modern lifts are after all movable stairways, and these economise time and labour. Another objection is risk of fire. This, doubtless, is a question deserving of every consideration, but it is a contingency, viewed in the light of past experience, which should not be allowed to bulk too largely. In such a type of building ground-space would be economised, and by architectural ingenuity efficient isolation may be secured. While the unit ward of a one-storeyed pavilion is thus rectangular in shape, and possesses windows on each side, a two-storeyed or three-storeyed building on this principle would but duplicate or triplicate the essential conditions named, and would adequately meet the case, provided that each pavilion block were sufficiently far separated from its neighbours that neither free movement of air nor admission of sunlight would be obstructed. At the same time such blocks might be united at right angles to their length by a connecting corridor, covered above but open on the sides, like the connecting bar of the letter H. A hospital constructed of circular wards, however, would so far meet the conditions of the pavilion type.

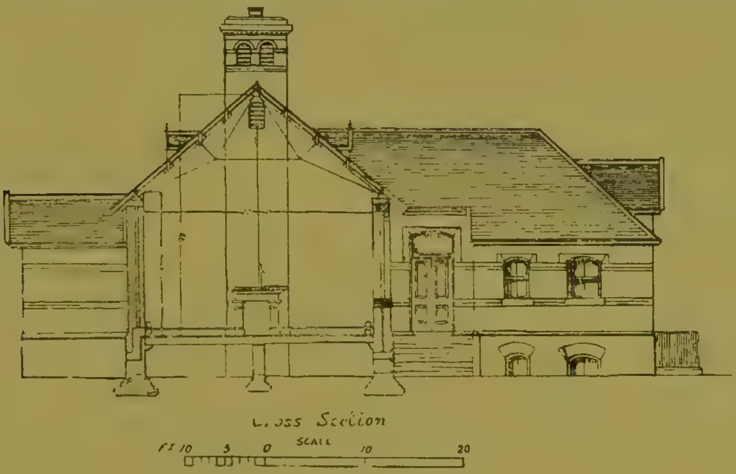

Fig. 125.—Cross-Section Plan of Ward in Belvidere Fever Hospital, Glasgow.

The second type of hospital may be called the *Block type*, where the buildings are separated in blocks, and thus each block becomes practically a separate hospital having a separate entrance with a central staircase, from the landings of which would pass the wards which are rectangular in shape, and which would or would not possess windows on each side. This is a favourite Continental method of constructing hospitals; but to be efficient the system requires considerable land, and administration is difficult.

Another type is the *Corridor* Hospital, in which there is a central corridor from which pass the wards which lie parallel to the line of corridor. The objection to this type is that there is no cross-ventilation, because the windows are only on one side of the room, although the beds are upon both. In such cases, one set of patients look out upon the sky, and the other upon the wall separating the ward from the corridor. In such a ward, effective isolation is impracticable although administration is easy, but ventilation by natural means can hardly be efficient; besides, the entrance of sunshine is necessarily much more limited. So long, however, as the need for an abundant and pure supply of air and of as much sunshine as is possible are important factors in the treatment of all diseases, and more especially of infective diseases, so long will architectural methods require to conform to the type of building in which these are best and most easily secured, and that type is to our mind the pavilion type, although not necessarily a one-storeyed building. Exigencies of space, economy, and other considerations may sometimes compel the erection of two-storeyed pavilions, but where cost of land is an unimportant item, the ideal isolation-ward is a one-storeyed building of the pavilion type. One pavilion ought to be distant not less than from 40 to 60 feet from those adjacent, the precise distance depending upon the height of the pavilion. In the opinion of some, each pavilion should be connected with the rest by connecting corridors, which should consist merely of covered ways entirely open at the sides. In our view such are neither necessary nor advisable.

Should the smallpox department be included within the general hospital-area, it ought to be separated by a high boundary-wall, in addition to the sanitary zone of 150 feet already mentioned. Compatible with reasonable economy, too, the smallpox pavilions ought to be separated further from each other than in the case of pavilions for the other infective diseases.

Another type of hospital, however, has been devised by Henman, which has in fact been constructed in the Belfast Royal Victoria Hospital. The principles of its construction were intended to overcome the administrative difficulties of the single-storey pavilion type which, covering of necessity a large area of ground, causes the staff to traverse considerable distances from the administrative block. This, it was believed, could be overcome by spreading out one-storey wards side by side, and by lighting them with lantern lights. By this arrangement the area of work to be supervised would be concentrated, corridor communication would be minimised, there would be no stairways or lifts as in the block or corridor systems, and abundant ventilation could be secured by mechanical methods. In the Belfast Hospital these views have been reduced to practice, and the novelty of the plan is that wards and accessory rooms are placed side by side with no space between. All these rooms are on one floor-level practically under one roof, and are entered by short corridors which open from a main corridor running at right angles to the lengths of the wards. Being a general hospital, there are medical, surgical, and other wards, and being in conjunction with a medical school, there is a large " extern " department, a pathological department, and a lecture-theatre all on the same level. The administrative block, which consists of four storeys, is on the north side of the main corridor. The axis of the wards is almost north and south. At the south end of each ward is a large window opening out upon a covered balcony, and from the window the view is extensive. Along the roofs of the wards are placed lantern lights so that sunlight may freely enter. The whole building is ventilated by the " plenum " system, the air being conveyed by ducts which are accessible for cleaning. The air-supply is ten million cubic feet hourly, which is equal to a total change of air ten times hourly night and day, throughout the entire wards. In the opinion of the architect there need be no risk of the spread of infection in a hospital so planned, since each ward is separately supplied with fresh air, and the foul air from each ward is independently discharged. In the discussion which followed the reading of the paper in which the plan of this hospital was fully described, the question of efficiency of lighting was raised, and a representative from Belfast stated that the building was not only well lighted, but from the position of the hospital had also a cheerful outlook.[1]

Ward-Space.—The cubic and superficial spaces to be allotted per bed ought to be considerably greater than those in a general hospital, on the principle that free dilution with fresh air diminishes the virulency of infective matter. The minimum cubic space should not be less than 2000 feet; a still more desirable amount is 2500 feet. The minimum floor-space should at least be 144 square feet, and, if possible, 180 square feet. These minimum conditions are secured in a ward of the following dimensions—viz. 24 feet wide, 14 feet high, with 12 feet of wall-space per bed; the larger requirements in one which measures 26 feet in width, 14 feet in height, with 14 feet of wall-space per bed. In some modern hospitals, as Bristol, the cubic space per patient is 2800 feet, and the superficial space 180 square feet.

Lighting.—Plentiful light is a prime essential of every hospital, but more especially of isolation hospitals, by reason that light, and more particularly sunlight, is one of the best natural germicides. Window-space should, therefore, have a distinct relation to total cubic space of a ward, and the proportion between the former and the latter should not be more than one square foot of window space to forty cubic feet of the latter, and should not be less than one to seventy. Unless special measures be taken for the conservation of heat, the ratio of one to forty-five makes the heating of a ward difficult. This, however, may be overcome by having double window-casements, or double glazed plate-glass windows. In temporary wooden hospitals, even with a ratio of one to seventy it is practically impossible to sustain sufficient temperatures, unless the walls are double and the interspace is filled with such a non-conductor as sawdust.

Heating.—Hospitals are usually heated: (1) by hot-water pipes at ordinary pressure; (2) by open fires; or (3) by a combination of both. Where a hot-water system is to be installed, the engineer must carefully calculate the extent of piping necessary, according to the general rules which have been already explained.

Ventilation.—In many hospitals, heating and ventilation are combined, whereas in others provision is only made for the entrance of fresh air at the outside temperature, or by passing the incoming air over a heated surface of pipes. There can be no doubt that the best means to obtain efficient ventilation is to purify, warm, and impel fresh air into the wards of a hospital, since by previous warming the air can be introduced at a greater velocity with comfort and safety. This is particularly of moment in convalescent wards. Another mode is to warm the incoming cold air by passing it over hot-water pipes, and to exhaust the foul air by the ward chimneys, or by special exhaust-flues built around or alongside the smoke-flues, and by roof-ridge fixed ventilators. A third mode is to permit the air to enter by Sheringham valves or Tobin's tubes, aided if necessary by cross-window ventilation when required, and to leave the heating to the hot-water piping and the ward fires. The recent tendency in the building of new hospitals to combine a scheme of heating and ventilation is unquestionably in the right direction, and probably the Key system is the best at present, the principles of which have been already explained. The advantages which this system possesses are, that purified warmed air may be impelled at uniform velocity into the wards in cold weather, and purified cooled air in warm weather, and also that the supply of such air is constant.

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[1] *Jour. San. Inst.*, vol. xx., Part iv., p. 599.

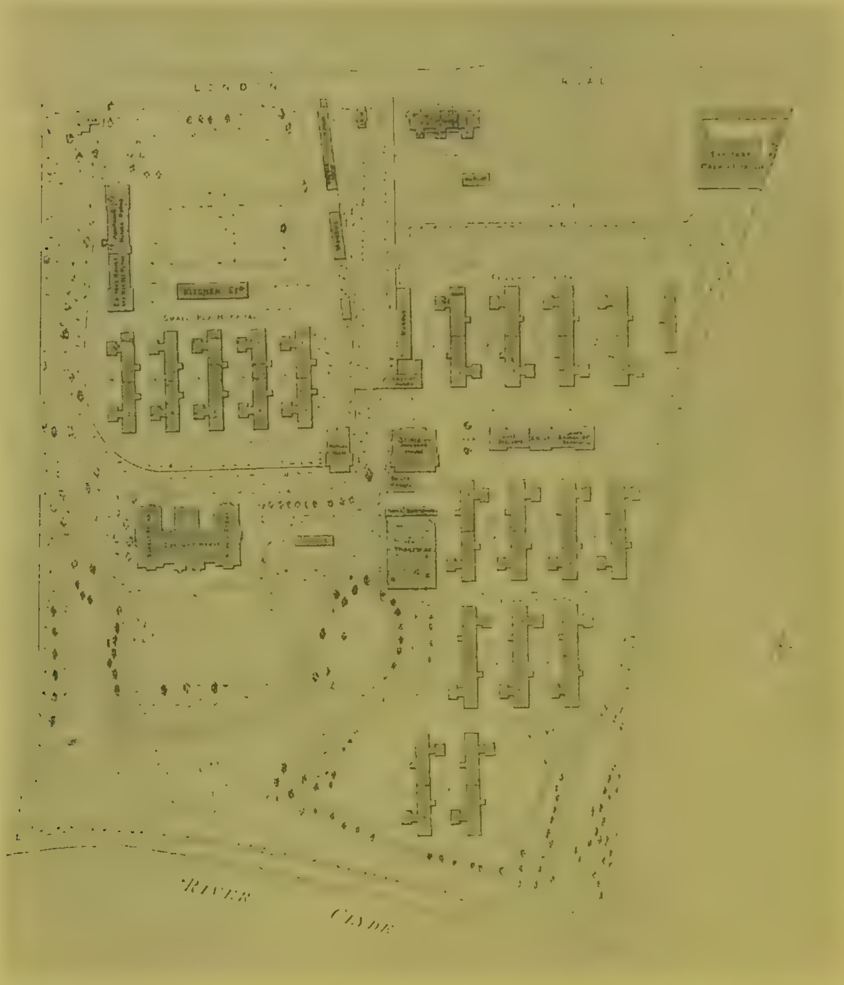

FIG. 126.—City of Glasgow Hospitals, Belvidere. Block Plan. This plan shows the disposition of different parts of the Hospital. If a line be drawn through the centre of the figure from top to bottom, and a second, at right angles, through the centre, the buildings devoted to the Fever Hospital will be seen to occupy the two quadrants to the right, and the lower quadrant to the left. The Smallpox Hospital occupies the upper left quadrant, and is separated from the other buildings by a surrounding, high, brick wall.

One of the principal objects in securing that an isolation hospital should be surrounded by a free open space is that the micro-organisms which pass into the air from infective wards may be destroyed by the action of freely diluted air. It has, however, been deemed advisable in certain places as Nottingham, Bradford, Blackburn, and others, to subject the outgoing air from such hospitals to the influence of the heat of a furnace. In the Western Fever Hospital, London, such an apparatus has been installed to extract and purify the air of two wards. These, however, are mainly intended to act as the motive power in a vacuum system of ventilation, although at the same time they purify the outgoing air. In Barry's Report on this subject to the Local Government Board of England much interesting information will be found. More recently, however, Henman has conceived the idea of filtering the exit air from hospitals by the moist screen used for the inlet air in Key's system, but applied to the outlets and on a smaller scale. He proposes

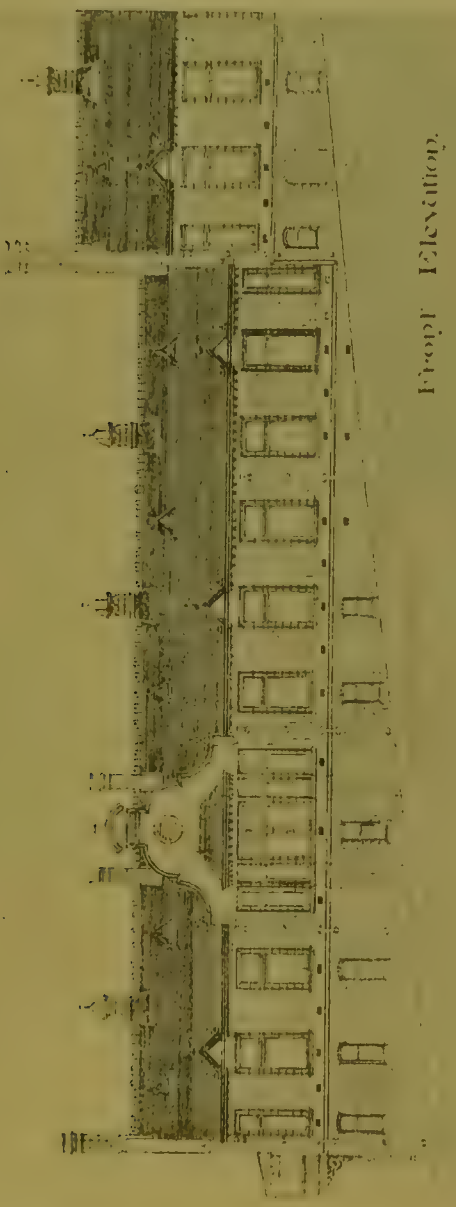

FIG. 127.—Front Elevation of a Ward in Ruchill Hospital, Glasgow. At the extreme left of the figure, abutting on the end of the ward, will be seen a conservatory for the use of convalescents.

that in the outlet at the head of each bed in the ward a small screen should be placed, which might, if thought advisable, be moistened automatically with a disinfecting fluid.[1] Whether, however, this proposal will go further than the experimental stage, in which it now is, remains to be seen. But after this comes the question, Is it necessary? For there is little evidence, except in smallpox, to show that isolation hospitals constructed in conformity to legal requirements are a source of infection to the surrounding population.

Typical Isolation Hospitals.—The following may be taken as typical isolation hospitals on the large and small scale for an urban and a rural community respectively. They have been selected because they are excellent types, and because they have been constructed to meet the most modern requirements. These are Belvidere and Ruchill Hospitals, Glasgow, the New Fever Hospital, Edinburgh, the Dunfermline Combination Hospital, and the Lanarkshire Middle Ward, Motherwell.

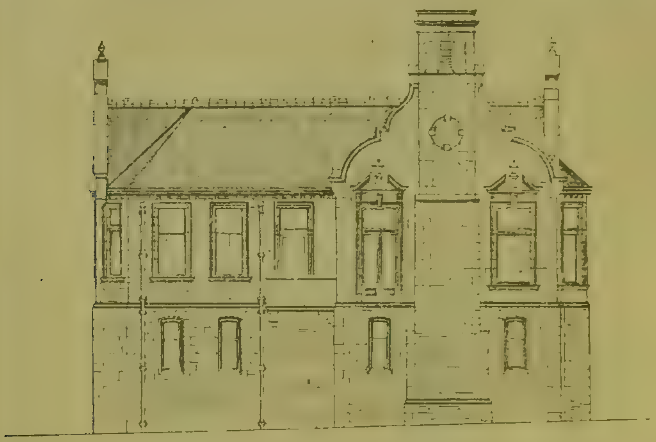

FIG. 128.—End Elevation of Ward, Ruchill Hospital.

Ruchill Hospital is situated in the northern outskirts of the city, of easy access by road and rail, and, planted upon a rising ground, it provides accommodation for over 400 beds. It is composed of the following blocks, viz.: (1) administrative; (2) isolation wards; (3) inquiry; (4) wash-houses and disinfecting; (5) kitchen and stores; (6) day workers' block; (7) clearing-house and fire-engine station; (8) morgue; (9) boiler-house and workshops; (10) stables; (11) cottages for principal non-professional officials. (Fig. 121.)

The isolation pavilions number sixteen in all, twelve large, and four small. At the sunny end of each, a balcony or verandah for convalescents is a prominent feature. Each large pavilion embraces two acute and two convalescent wards, the former for ten beds each, the latter for five beds each. The dimensions of a ward for acute cases are as follows: length, 66 feet; breadth, 22 feet; height, 15¾ feet; total superficies of floor, 1452 square feet; total cubic space, 23,100 cubic feet; window-space, 391 square feet; ratio of window-space to total cubic space, about 1 to 60. The dimensions of a ward for convalescent cases are exactly the same as for a small pavilion convalescent ward, as enumerated below. Each small pavilion contains two acute wards, and two convalescent wards. The dimensions of each ward in a small pavilion are these: length, 33 feet; breadth, 22 feet; height, 15¾ feet; total superficies of floor, 726 square feet; total cubic space, 11,550 cubic feet; window-space ratio (in acute ward), 1 to 62, and (in convalescent ward) 1 to 45. The total number of beds in the hospital amounts to 408. From the foregoing figures it will be seen that each patient receives 144 square feet of floor-space and 2300 cubic feet of air-space.

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[1] *Jour. San. Inst.*, vol. xv., Part iv., p. 641.

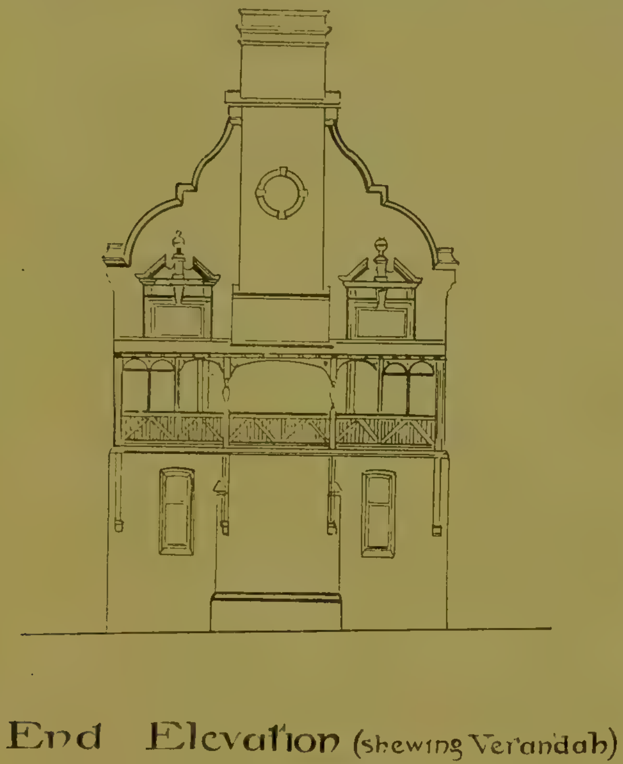

FIG. 129.—Ward of Ruchill Hospital.

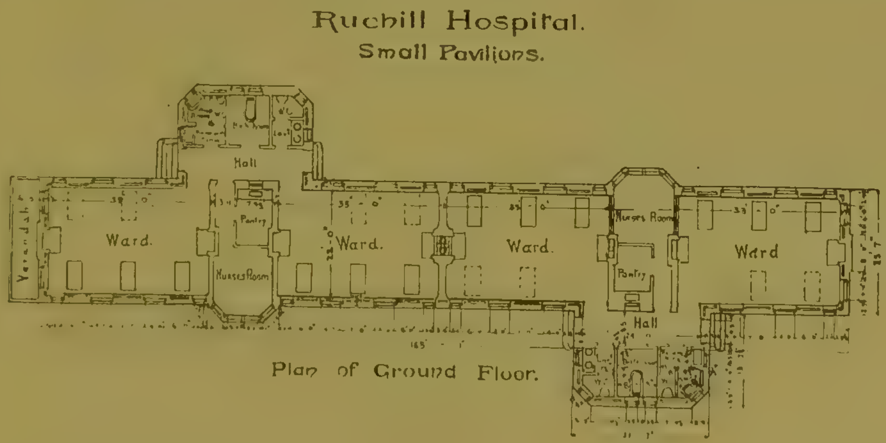

FIG. 130.

The ground-floor plan (Fig. 130) of a small pavilion shows the following accommodation—viz. four wards with five beds each, two nurses' rooms, two pantries, two bath-rooms, two lavatories and water-closets for patients, like accommodation for those on duty, two steep-rooms for soiled linen, etc. The wards are disconnected from the annexes, which contain the sanitary fittings, by a hall having opposite doorways into the outer air, and the nurses' rooms and pantries are situated between each pair of wards.

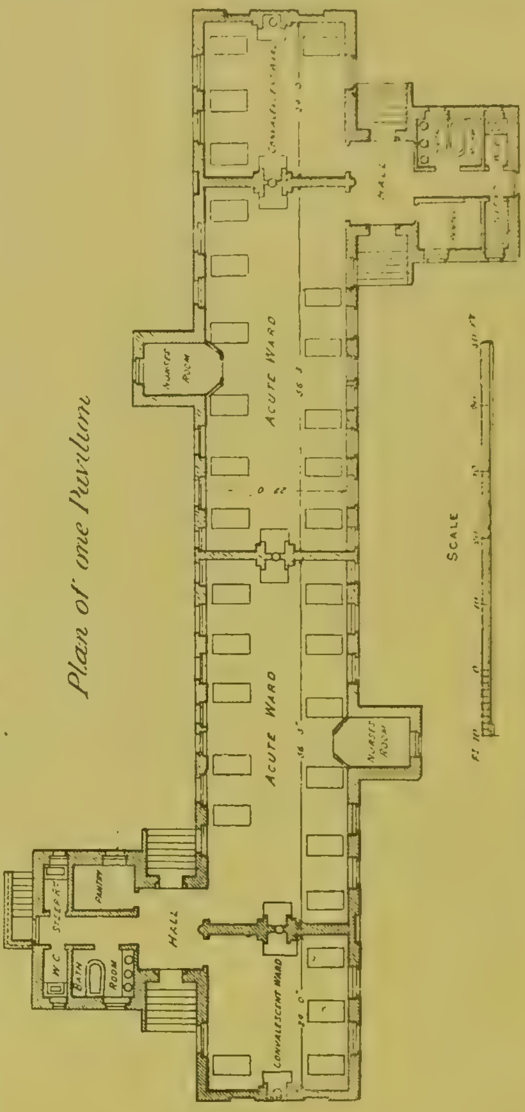

FIG. 131.—Ground Plan of a Pavilion in Belvidere Hospital.

A like plan of a large pavilion shows a similar disposition of arrangements, but on a correspondingly larger scale.

All angles in the inner walls of ward are rounded off in Parian cement, so as to prevent lodgment of microbic dust, and for easier cleansing.

The heating of the wards is effected by hot-water pipes at ordinary pressure, aided by open central ward fires. Ventilation is accomplished by fixed roof-ridge cowls, hopper-sashed windows, and by concentric outlet air-shafts placed round ward flues, the entrance of fresh air being effected by the windows which are provided as above, but which, also, are constructed with movable sashes.

This hospital is entirely devoted to the treatment of infective diseases other than smallpox, for the treatment of which ample provision exists in another hospital.

New Fever Hospital, Edinburgh.—This new hospital, which has been planned to include the most modern requirements of an isolation hospital, is located upon the estate of Colinton, on the southern outskirts of the city, occupies about 40 acres of land, and provides for the accommodation of 600 patients. The population of Edinburgh being about 300,000, the ratio of beds per 1000 of population is therefore 2 per 1000. The number of patients per acre is fifteen. The site of the hospital, which has a gentle southern slope, is about 400 feet above sea-level, and is freely open all around, especially on the south, east, and west. It is intended to place permanently the smallpox hospital upon this area of land, but at a satisfactory distance from the general isolation wards. The land is plotted out in buildings as follows: The main entrance is from the north, the buildings looking north and south.

Facing the entrance but further within it, and occupying a nearly central position in the grounds, are the following blocks, viz.: (1) general offices; (2) buildings for stores, kitchen, and dining-room; (3) nurses' and servants' homes. To right and left of these the ward pavilions are arranged, those on the left being entirely devoted to scarlet fever, while those on the right are set apart for diphtheria, enteric fever, erysipelas, measles, chicken-pox, whooping-cough, and typhus fever. The reception and observation wards are situated on either side of the main entrance, between it and the ward blocks, and the isolation wards for complicated cases, toward the further extremities of the respective ward-groups. At the north-east corner of the ground are: (*a*) ambulance-station; (*b*) lecture-rooms; (*c*) pathological laboratory; (*d*) museum and mortuary; and at the south-east corner (*a*) laundry and wash-houses; (*b*) disinfector, boilers, and incinerator. In the south-east corner, standing by itself, is the ward for typhus fever.

Provision has been made for the treatment of the diseases named above, and the incidence of bed-accommodation for these different diseases is shown in the following Table:—

TABLE XLVII

Ward Accommodation and Beds

Diseases	Pavilions	Beds		Totals for each Disease
	Blocks	In each Pavilion	In each Class of Pavilion	
Scarlet Fever—				
Observation	1	4	4	
Ordinary	6	46	276	
Convalescent	1	24	24	
Isolation	4	4	16	
				320
Enteric Fever—				
Observation	1	4	4	4
Ordinary	2	38	76	
Isolation	1	4	4	
				80
Typhus Fever	1	10	10	10
Diphtheria	1	30	30	30
Measles—				
Ordinary	2	38	76	
Isolation	1	4	4	
				80
Chicken-pox	1	19	19	19
Whooping-cough	1	19	19	19
Erysipelas	1	30	30	30
Probationary	2	4	8	8
	Total Number of Beds			600

Between the ward pavilions, which are two-storeyed, and whose axis lies north and south, there is ample space for recreation, which, however, is further provided for in other parts of the grounds.

Besides the general wards, each pavilion has on each floor a two-bed and a single-bed ward for special or private cases.

The walls of the wards are composed of Keene's or Parian cement, with rounded hollows at re-entrant angles.

Heating of wards is effected by ventilating steam-coils and by ventilating stoves, and in the smaller wards by ventilating grates. Cross ventilation by opposite windows is the chief means of ventilation of wards. By means of covered ways, the staff may pass protected from the weather from the administrative department to the pavilion blocks. These ways, although roofed, are largely open on the sides. This covered way does not extend, however, to the typhus-fever ward, which is of one floor only, the walls of the ward being raised on built piers, so that air may freely circulate below the building. (*Vide* Fig. 132).

TABLE XLVIII

Spaces Allowed per Bed

Disease	Cubic Space per Bed	Superficial Space per Bed
Scarlet Fever	2000	156
Whooping-cough Chicken-pox }	1690	130
Diphtheria	2545	195
Enteric Fever	2514	194
Measles	1690	130
Typhus Fever	3042	254
Erysipelas	2028	156

From the foregoing Table it will be seen that both cubic and floor space have been regulated and fixed by the ages of the likely occupants, and by the character of the infectivity of each disease.

The Dunfermline Combination Isolation Hospital is a very excellent type of rural hospital. It occupies a site the area of which is 2½ acres with a southern exposure, and with a good fall for drainage.

The hospital consists of a central administrative building which is flanked by two semi-detached " quarantine " wards for the reception of doubtful cases. Behind this block, and on each side—west and east—is an isolation pavilion, which is from 40 to 60 feet distant from the administrative block. These pavilions are connected with the administrative block by means of open covered ways. The offices are placed in the extreme west angle of the site, between which and the western pavilion sufficient space has been left whereupon to build another pavilion, if and when such extension is required. In the lower right angle of the site it is proposed to erect accommodation for the principal officials.

A sanitary zone of 40 feet separates at all points the buildings from the public road.

The fever pavilions are situated north and south. They are simple in design, being founded largely upon the plan of the Warrington

Fever Hospital, and are so arranged that each window of the ward may receive the rays of the sun during several hours of the day.

The administrative building, placed on the southern side of the site, contains kitchen, store-rooms, rooms for physician and matron on the ground-floor, and three large bedrooms, with bath-room and napery stores upstairs, while in the basement the air-warming chamber, air-propelling fan, and steam-engine for driving the fan are located. The probationary or "quarantine" wards, although they flank the former building, are wholly isolated from it and from each other. They may be overlooked, however, from air-tight windows from the administrative building. They are entered by separate doorways outside of the administrative block. Each ward—one for each sex—measures 24 feet long, 12 feet broad, and $14\frac{1}{2}$ feet high, and thus contains 4176 cubic feet of air-space. Each is intended for two beds, so that each

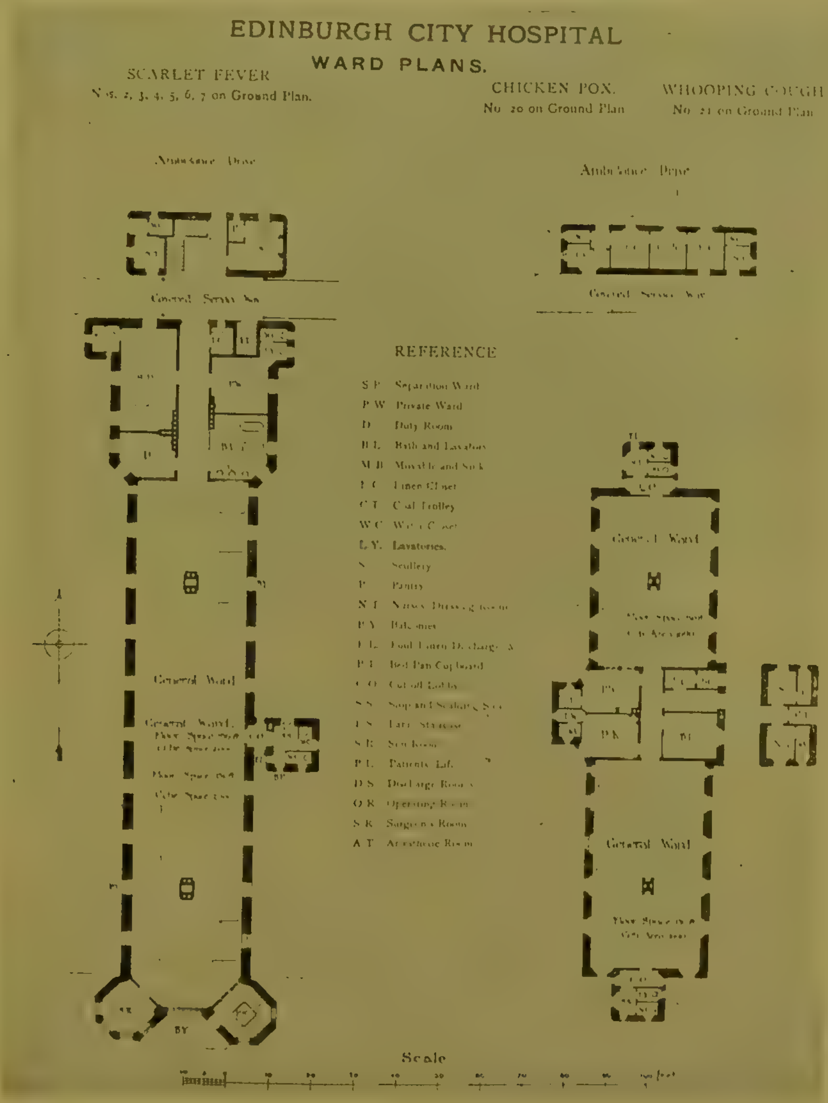

FIG. 132.

occupant has allotted to him over 2000 cubic feet of air-space, 12 feet of wall-space, and 144 square feet of floor-space.

Each isolation block contains one ward for males, and one for females. Each ward, on either side of the administrative block, has six beds, while those in the block behind, being smaller than the others, have only four beds. The latter are intended for convalescent patients when circumstances are suitable. In each of these wards, the measurements provide the following spaces per bed—viz. 2000 cubic feet of air-space, 144 square feet of floor-space, and 12 feet of wall-space. The present total number of beds is 36; the number of beds per acre is therefore about fourteen.

All the outer walls of the hospital wards are of hollow formation, the inner layer being of brick finished in adamant plaster, the outer of stone, with an intervening air-space of three inches. All the corners in the walls, floor, and ceiling are rounded, so as to prevent lodgment of dust. Woodwork has been as sparingly used as possible because of its absorptive properties, and had objections not been offered by the Local Government Board, the floor would have been laid in granolithic instead of wood.

The offices consist of a wash-house, laundry, ambulance-shed, mortuary, and a small disinfecting chamber for the use of sulphurous acid gas. Disinfection by heat is also provided for in a separate apartment by a Washington-Lyon disinfector of the type formerly described.

The heating and ventilation of the whole hospital are combined in one scheme—viz. by Key's *plenum* system. The air of the administrative block is changed six times, and of the isolation pavilions eight times per hour day and night, and the system is guaranteed to supply air at a uniform temperature of 62° F.

The drainage-system is excellent. The drain-pipes are laid in straight lines, are of as small size as is necessary, and are provided with man-holes and inspection-openings at all angles and junctions. The drains of each block of buildings are entirely disconnected from one another and from the main drain by ventilating traps, while the main drain itself is ventilated by the exhaust power of the heated air of the chimney-stalk at the offices, by which a current of fresh air with a velocity of 700 feet per minute is passed through the drain.

The Middle Ward of Lanark Hospital (Fig. 133) stands on an elevated site overlooking the Clyde valley and comprises six acres of ground. It has been planned for 100 adult patients in the following pavilions—viz. four pavilions of 20 beds each, with eight private wards of one bed each; one isolation pavilion of 6 beds; and one observation pavilion of 6 beds. The buildings are plotted out on the site in the following manner: At the entrance lodge are situated a waiting-room for the use of patients' friends, and the inquiry-room; the administrative block occupies a detached position in front of the hospital site, and the kitchen and service department, a central and convenient position for distribution of food. A nurses' home has been added.

The four main pavilions are built with their axis north and south, thereby permitting of the fullest amount of available sunlight. Each pavilion is divided into two wards of 10 beds each, and has two separation-wards of one bed each attached. The nurse's room is placed between the wards in such a position that by means of windows she can overlook both the main and separation wards. Each main ward has the following dimensions—viz. length, 60 feet, breadth, 26 feet, height, 13 feet. The total gross cubic space is therefore 20,280 cubic feet, and the total superficies or floor-space, 1560 square feet; thus each patient is allowed 2028 cubic feet, 156 square feet, and 12 feet linear wall space. All internal wall-angles of wood and plaster-work are rounded or hollowed for easier cleaning. All the walls of the wards are faced externally with stone, lined on the inside with brick, a hollow space intervening for ventilation. The lathing of walls and ceiling is composed of steel. The lighting of the wards is accomplished by means of windows which extend from 2½ feet from the floor to the ceiling. These are constructed of double-hung sashes to three-fourths of the height, with a hinged hopper fanlight at the top which opens inwards. All the ward windows are double-glazed with sheet glass. There is a window between each bed. At the southern end of each pavilion there is a verandah for the use of convalescent patients. Attached to each pavilion is a suite of undressing, bathing, and dressing rooms through which patients have to pass for toilet purposes on admission to and dismission from the hospital.

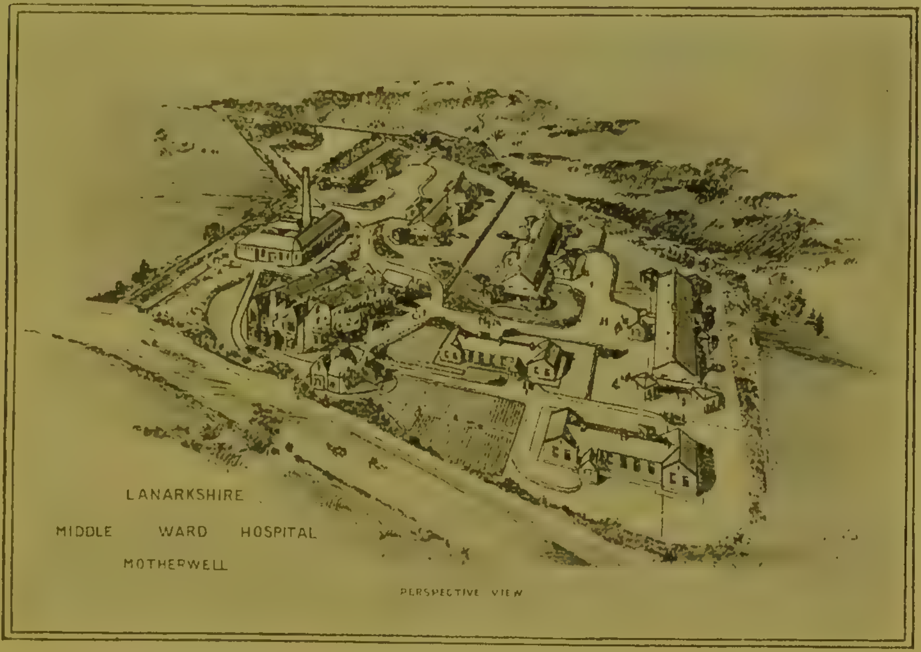

FIG. 133.—This Hospital contains 100 beds for Infective Diseases. At the entrance is the Porter's Lodge, and adjacent to it is (2) Administrative Block. Behind and to the left is the block containing Laundry, Mortuary, Destructor, and Disinfecting Apparatus. Ranging along the back are Four Main Ward Pavilions, which are situated north and south, at the south end of which is a Verandah for convalescents. The two first Pavilions facing the reader are Isolation and Observation Pavilions The site of the Hospital extends to about six acres, and occupies an elevated position.

The wards are heated by means of (*a*) open fireplaces and (*b*) low-pressure hot-water piping. The latter is placed under the floor, and by branches from these pipes radiators in the wards are supplied. These radiators are placed against the external walls under each alternate window, and two circular radiators are fixed in the centre of the ward to secure equalisation of temperature. The ventilation of the wards is achieved by means of the hopper fanlights of the windows, and the double-hung sash-windows themselves. The window-radiators act in combination with fresh-air inlets regulated by valves, and thus warmed air is admitted. The exhaustion of foul air is attained by putting vertical exhaust shafts in the end walls, and Honeyman's ventilators in the ceilings. Each of these vertical shafts is fitted with a steam coil to ensure the upward movement of air.

The drainage arrangements are constructed on the separate system —one set of pipes carries away rain and surface-water, another set the sewage. The drains are laid in practically straight lines, with inspection man-holes at connections, and with necessary traps and ventilators. The sewage is purified before leaving the grounds of the hospital by means of tanks and filters, which can be worked continuously or intermittently, with or without the use of chemicals, and in such a way as provides for aeration of the filters. All hospital waste, kitchen refuse, bedding, or other infected material which is to be got rid of, is burned in a destructor also erected within the grounds, Disinfection is accomplished in a non-jacketed disinfector, made by Messrs Goddard, Massey, and Warner.

The mortuary is so arranged that through a fixed window relatives may look upon the faces of their dead.

Another commendable feature of this hospital is the provision of a complete system of subways connecting the various buildings. In these are located steam and water mains, wires for electric light, telephone, etc., and workmen are able to pass through them from one point to another of the hospital, thus making it unnecessary for them to enter an infected ward for examination of fittings or repairs.

The total cost of the hospital, including fittings, apparatus, machinery, furniture, etc., was about £37,000, or £370 per bed.

It will therefore be apparent that the hospitals described exhibit all the important modern improvements in construction, with some points of novelty in each case, and may therefore be taken as most illustrative of the most advanced types.

Law respecting Provision of Isolation Hospitals

The law of England respecting hospital provision is contained in :

I. The Public Health Act, 1875, Sections 131–133 ;
II. The Isolation Hospitals Act, 1893 ; and
III. The Isolation Hospitals Amendment Act, 1901.

I. The Public Health Act, 1875.

Power of L. A. to provide Hospitals.

Section 131. Any L. A. may provide for the use of the inhabitants of their district hospitals or temporary places for the reception of the sick, and for that purpose may—

Themselves build such hospitals or places of reception ; or contract for the use of any such hospital or part of a hospital or place of reception : or

Enter into any agreement with any person having the management of any hospital, for the reception of the sick inhabitants of their district, on payment of such annual or other sum as may be agreed on.

Two or more Local Authorities may combine in providing a common hospital.

Section 132. Provides for the recovery of cost of maintenance of patient, not a pauper, in any such hospital from such patient, or, in the event of his death, from his estate.

[*Note.*—The P. H. Acts Amendment Act, 1907, section 60 (adoptive), provides that the L. A. may pay the expenses of a person in hospital, not a pauper, when the circumstances are such as to justify the remission of the debt. (*Vide* p. 473.)]

Section 133. Gives power to a L. A., with the sanction of the L. G. Board, to provide or contract with any person to provide a temporary supply of medicine and medical assistance for the poorer inhabitants of their district.

II. The Isolation Hospitals Act, 1893—Lord Thring's Act—was passed to enable County Councils to establish hospitals for persons suffering from infectious diseases ; and

III. The Amending Act, 1901—

Was passed to amend certain provisions of the Act of 1893.

Neither of the Acts applies to Ireland, London, Scotland, or to any English county borough, or to any borough of 10,000 or more inhabitants, unless the borough council consent, and shall only apply to any borough of less than 10,000 inhabitants if the council consent, or the Local Government Board direct that the Act shall apply thereto.

In the Act of 1893 as amended by the Act of 1901 ;

Section 3. Gives power to any County Council to provide such a hospital in any district of their county when application has been made and sufficient reasons have been given to support such application.

Section 4. Declares that such an application may be made (1) by one or more Local Authorities having jurisdiction in the county or any part of it after the passing of a resolution to that effect at a meeting duly called for the purpose, and (2) by not fewer than twenty-five ratepayers in any contributory place.

Section 5. (1) Declares that the application shall be made by petition, stating the district for which the hospital is required, and adducing reasons therefor. (2) That the C. C., or a special committee, shall consider the prayer of the petition, and if they are satisfied that a *prima facie* case is made for holding a local inquiry, they shall cause such local inquiry to be held.

Section 6. Empowers a C. C., without any application from a Local Authority, to direct the M. O. H. to inquire as to the need for the establishment of such a hospital in any particular district, and, on an affirmative report, to proceed as if the application had been made as in section 4 (1).

Section 7. The C. C. shall conduct the inquiry with reference to (1) the necessity for establishment of such a hospital, (2) the proper site for the same, and (3) the district for which it is to be established, by a committee of such number of their members, either with or without additional persons, or in such other manner as the Council think expedient. Due notice as to time and place of inquiry shall be given in such manner as the C. C. may think best fitted to inform any persons interested, and any interested persons may attend and state their case.

Section 8 (as amended by section 5 of the Act of 1901). (1) A hospital district shall consist of one or more local areas, such local area being (*a*) an urban sanitary district, or (*b*) a rural sanitary district, or (*c*) a contributory place.

(2) The C. C. may vary any hospital district by adding to it or subtracting from it any local area. If any local area is, in their opinion, already sufficiently provided with hospital accommodation, it shall not, unless with the assent of the Local Authority of such area, be included in a hospital district under this Act.

(3) If any L. A. having jurisdiction within the proposed hospital district object to the formation of such a district, or to any addition to or subtraction from the district of any local area, they may appeal to the L. G. Board against any order within three months of the date of such order.

[*Note.*—Section 6 of the Amending Act of 1901 empowers the L. G. Board to confirm, disallow, or modify the order after considering the appeal.]

Section 9 (as amended by section 7 of the Act, 1901). After conclusion of local inquiry, the committee of the C. C. shall make an order either dismissing the petition or constituting a hospital district, and directing the establishment of such hospital. The C. C. shall send a copy of any such order to the L. G. Board. No order shall be made constituting a hospital district for one or more contributory places forming a part of a rural sanitary district, or for one local area, unless the L. A. concerned consents or is unable or unwilling to provide such hospital accommodation.

Section 10 (amended by section 8 of the Act of 1901). Deals with the formation of a " Hospital Committee " by the C. C., when the hospital district has been constituted. Such Committee may consist solely of members of the C. C., or partly of such members and partly of representatives of the local area or areas in the district, or wholly of such local representatives. The C. C. shall make necessary regulations regarding the constitution, election of the Committee, and other matters relating thereto.

A Hospital Committee shall have power to acquire land and such other powers relating to the hospital as the C. C. may delegate to them, and shall be a body corporate, having a perpetual succession and a common seal. The C. C. shall retain power to inspect such hospital and to raise money for hospital purposes.

Section 11. Deals with the purchase of land for such hospital.

Section 12. Empowers the Hospital Committee to make necessary rules and regulations for the conduct and management of the hospital and of patients.

Section 13. Declares that every isolation hospital shall be provided with an ambulance or ambulances, and, as far as practicable, be in connection with a system of telegraphs.

Section 14. Empowers such Hospital Committee, in expectation of or in the event of any outbreak of infectious disease, to provide additional accommodation for the reception of infectious patients, in such form and manner as they may deem expedient; or, before the permanent hospital is established, may provide temporary accommodation.

Section 15. Subject to any regulations made by the C. C., the Hospital Committee may make arrangements for training nurses to nurse infectious patients, inside or outside the hospital, and may charge for outside nursing.

Section 16. (1) There shall be charged with respect to every person admitted into the hospital such sum as the Committee may think sufficient to defray the expenses in this Act defined as " patients' expenses." If any patient be admitted to the hospital from beyond the hospital district, an extra charge shall be made as a contribution towards the cost of the provision of the hospital.

(2) Persons desirous of being provided with accommodation of an exceptional character may be so provided on their undertaking to pay for the same a sum fixed by the Committee, and also to pay for all other expenses incurred in respect of their maintenance in the hospital, such expenses being in this Act referred to as " special patients' expenses."

Sections 17 and 18. Deal with classification of expenses and payment of the same, except patients' and special patients' expenses.

Section 19. Declares (1) If a patient be a pauper or has been in receipt of parochial relief within fourteen days before admission, the Union Guardians shall pay his expenses; (2) If he be a non-pauper patient, the L. A. of the local area whence he came shall pay out of the local rates; (3) the extra charge for any patient coming from beyond the hospital district shall be payable by the L. A. of that place out of the local rates; (4) special patients' expenses shall be payable by the patients themselves; and (5) the expenses of burial of any patient dying in hospital shall be payable by the L. A. sending him to hospital.

Section 20. Gives power to a C. C., on application of the Hospital Committee, and with consent of any L. A. concerned, to alter any order made by them for establishment of a hospital.

Section 21. Gives power to a C. C. to contribute out of the county rate a capital or annual sum towards structural and establishment expenses of a hospital, or to one or other class of such expenses.

[*Note.*—This is amended by section 1 of the Act of 1901 as follows :—(1) Any L. A. which has provided a hospital under any other Act may transfer the same to the C. C. with the sanction of the L. G. Board and the assent of the C. C. Such a hospital may be used as an isolation hospital and be treated as if it had been erected under the Isolation Hospitals Act, 1893.]

Section 22. Empowers the C. C. to borrow money for the purposes of this Act.

Section 23. Enacts that no person, by reason of his being admitted into and maintained in any hospital established under this Act, shall suffer any disqualification, or any loss of franchise, or other right or privilege.

Section 24. Applies section 87, sub-sections 1 and 5, of the Local Government Act, 1875 (power to hold inquiries by the L. G. Board), to the purposes of this Act.

Section 25. Deals with audit of accounts.

Section 26. Defines a "local area" to be any urban sanitary district, rural sanitary district, or contributory place, and a "Local Authority" to be, in an urban sanitary district, the urban sanitary authority, in a rural district, the rural sanitary authority, and, in a contributory place being a parish, the vestry or other authority having the powers of a vestry.

The law with regard to Temporary Shelter or House Accommodation in England, the equivalent of the Reception House in Scots law, is contained in—

I. The Infectious Disease (Prevention) Act, 1890, section 15; and

II. The Public Health Acts Amendment Act, 1907, section 61 (adoptive).

The terms of section 15 of the first-mentioned Act are as follows :—

The Local Authority shall from time to time provide, free of charge, temporary shelter or house-accommodation with any necessary attendants, for the members of any family in which any infectious disease has appeared, who have been compelled to leave their dwellings for the purpose of enabling such dwellings to be disinfected by the Local Authority.

(For the terms of section 61 of the second-mentioned Act, *vide* p. 471.)

Scotland.—The law in Scotland respecting Isolation Hospitals and Houses of Reception, etc., differs in no essential respect from that of England, except, perhaps, with respect to the liability of a patient in an isolation hospital for the cost of his treatment and maintenance. There is, certainly, no statutory provision on the subject in the law of Scotland ; while a Local Authority are empowered to provide hospital-accommodation, medical attendance, nursing, and maintenance, for infectious patients, they have no power to recover the cost from the patient or his relatives. The case is entirely different where one Local Authority contracts with another Local Authority with regard to the treatment of their patients in the hospital of the other Authority, since part of the contract will consist in the sum to be contributed per patient by the one Authority to the other.

The law is contained in the—

Public Health (Scotland) Act, 1897.

Section 66. (1) Any Local Authority may, and if required by the L. G. Board shall, provide, furnish, and maintain for the use of the inhabitants of their district suffering from infectious disease, hospitals, temporary or permanent, and houses of reception for convalescents from infectious disease, or for persons who have been exposed to infection, and for that purpose may—

(*a*) themselves build such hospitals or houses ; or

(*b*) contract for the use of any such hospital or house or part thereof ; or

(*c*) enter into any agreement with any person having the management of any such hospital or house or part thereof on payment of such annual or other sum as may be agreed on ;

(*d*) any Local Authority, with consent of the Board, may also or in place of providing such hospitals or houses as aforesaid, employ nurses to attend the persons suffering from infectious disease in their own houses, and also supply medicines and medical attendance for such sick.

(2) Two or more Local Authorities may, and if required by the Board shall, combine in providing, furnishing, and maintaining a common hospital or house of reception, or in employing nurses on terms to be agreed on, and failing agreement, to be fixed by the Board, whose determination shall be binding.

(3) No contract for the use of any such hospital or house or part thereof shall be entered into without the consent of the Board, and no hospital or house of reception shall be provided, unless and until the site and plans for the construction thereof have been approved by the Board. Provided always that such site shall be in or within a convenient distance of the district of the Local Authority, or in the case of a combination in terms of this section, in or within a convenient distance of the combined district.

(4) A Local Authority may with the sanction and subject to regulations made by the Board provide and maintain one or more portable hospitals for the use of their district.

Section 47, sub-section 4, also empowers a Local Authority to provide places of temporary shelter, or house-accommodation. (*Vide* p. 470.)

Section 141. Gives power to a Local Authority to borrow for furnishing as well as for providing hospitals.

Sections 144 and 145. Give power to a Local Authority to acquire land compulsorily for the purpose of a hospital.

[*Note.*—A district committee of a County Council, although the Local Authority for their district, is not empowered to acquire or hold lands, and where land for a hospital has to be acquired and held for this purpose in the district of a county, such must be acquired and held by the County Council.

For requirements as to sites for Smallpox hospitals, as laid down in a Memorandum of the English Local Government Board, see p. 489.]

CHAPTER XVI

LAW AS TO NUISANCES

Public Health (Scotland) Act, 1897, Part II.

Under the Public Health (Scotland) Act, 1867, it was necessary in the bulk of cases to prove actual injury to health from a nuisance. Under the present Act of 1897, the conditions have to be proved to be *a nuisance or injurious or dangerous to health.* The introduction of the word "dangerous" enlarges the scope of the possible effects of a nuisance, in respect that a Local Authority is now only called upon to show that any existing condition is likely to prove prejudicial to health, and not that it has caused actual injury to health. A nuisance has been defined by Lord Chancellor Selbourne as follows :[1]—"What causes discomfort and annoyance for the ordinary purposes of life to a man's house or to his property, is to be restrained, subject of course to findings which the particular circumstances of the particular case may raise ; and, although the evidence does not go to the length of proving that health is in danger, I will say no more than that the conclusion seems necessarily and properly to follow."

The terms "*offensive*" and "*offensiveness,*" used in section 16 of the Act of 1867, were defined in the opinion of counsel (Lords Young and Gordon and Sheriff Monro, then counsel) thus :—"Offensiveness must be such as seriously to interfere with the comfort of life in the neighbourhood, and such may be detrimental to health, although it should be impossible to prove that it has been or necessarily must be so." (Board of Supervision, Report 1872. App. p. 107.)

It is necessary that the student should distinguish between statutory nuisances and nuisances at common law. All of the nuisances dealt with under section 16 of the Scottish Public Health Act, 1897, and section 91 the English Act of 1875, are, for example, statutory nuisances, and the procedure for dealing with these in the respective Acts named apply only to these, and not to nuisances at common law. A nuisance at common law, *per contra,* may be defined as any condition or circumstance which causes discomfort and annoyance for the ordinary purposes of life. According to section 170 of the P. H. (Scotland) Act, 1897, nothing in that Act shall be construed to impair any right of action in respect of nuisances at common law ; and according to section 171, all powers given by that Act shall be deemed to be in addition to and not in derogation of any power conferred by any unrepealed Act of Parliament or any law or custom.

The following are, in brief, the terms of **Section 16 of the Public Health (Scotland) Act, 1897 :—**

For the purposes of this Act—

(1) Any premises or part thereof of such a construction or in such a state as to be a nuisance or injurious or dangerous to health ;

[This sub-section applies to all premises inhabited or uninhabited, and it is not required to prove injury to health.

The Housing of the Working Classes Act, 1890, Part II., sections 30–41, deals with unhealthy dwelling-houses, and provides for the closure of any such house which is in a condition so dangerous or injurious to health as to be unfit for human habitation.

But the Act now under consideration has a wider scope. By the definition of the word "premises" (Section 3) this will be apparent; for as defined, it includes lands, buildings, vehicles, tents, vans, structures of any kind, *streams, lakes, seashore, drains, ditches, or places open, covered, or inclosed, whether built on or not, whether public or private, and whether natural or artificial*, and whether *maintained under statutory authority or not*, and *any ship, lying in any sea, river, harbour, or other water*, or *ex adverso of any place within the limits of the Local Authority.*]

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[1] Fleming and Hislop, March 1, 1886. 13 R (H. L.) 43.

(2) Any street, pool, ditch, gutter, water-course, sink, cistern, water-closet, earth-closet, privy, urinal, cesspool, drain, dung-pit, or ash-pit, so foul or in such a state or so situated as to be a nuisance or injurious or dangerous to health;

[It is to be noted that section 28 gives special powers for dealing with foul water-courses, ditches, gutters, or drains, and section 41, for cleansing open ditches lying near or forming boundaries of districts (*vide* p. 325), while sections 30 and 31 provide penalties for causing a drain, water-closet, or other sanitary convenience to be a nuisance by wilful damage to the same.]

(3) Any well or water-supply injurious or dangerous to health;

[A Local Authority have full power over public wells which they may close if found to be contaminated; and sections 127–129 provide penalties against the pollution of any well or place for water by any refuse from the manufacture of gas, naphtha, vitriol, paraffin, dye-stuffs, or other deleterious substances (*vide* p. 205). In the case of private wells, closure can only be effected by an order of the Sheriff if the closure be resisted by the owner. The examination may include chemical analysis, the cost to be charged to the public health rate.

Water is expressly excluded from the Sale of Food and Drugs Acts, 1875–1899.

The Dairies, Cowsheds, and Milkshops Order, 1885, clause 7, makes provision for a proper water-supply to a dairy before it can be occupied for that purpose.

Prevention of pollution of the water of streams for primary purposes may be attained by an action at common law.]

(4) Any stable, byre, or other building in which any animal or animals are kept in such a manner or in such numbers as to be a nuisance or injurious or dangerous to health;

[A Local Authority has power to make bye-laws respecting the construction, situation, and cleansing of pig-styes (Sect. 35), and to deal with insanitary condition of byres under the Contagious Diseases (Animals) Act, 1878, section 34, as amended by section 9 of the Act of 1886, and under the Dairies, Cowsheds, etc., Order of 1885.

In burghs, byres come under the provisions of the Cattle-sheds in Burghs (Scotland) Act, 1866, section 4; stables, byres, and areas connected therewith in burghs, under the Burgh Police (Scotland) Act, 1892, section 121; and any house, building, or premises kept so as to be a nuisance or source of annoyance to neighbouring inhabitants by the keeping of dogs, cats, fowls, or other animals, under section 316, B. (7) of that Act.]

(5) Any accumulation or deposit, including any deposit of mineral refuse, which is a nuisance or injurious or dangerous to health or any deposit of offensive matter, refuse, or offal or manure (other than farmyard manure or manure from byres or stables, or spent hops from breweries) within *fifty yards* of any public road wherever situated, or any offensive matter, refuse, or offal, or manure other than aforesaid, contained in uncovered trucks or waggons standing or being at any station or siding or elsewhere on a railway, or in canal boats, so as to be a nuisance or injurious or dangerous to health;

[This sub-section does not apply to manure being loaded or unloaded or in course of transit, nor shall a penalty be imposed in respect of any accumulation or deposit necessary for the effectual carrying on of any business, if it be proved that such accumulation or deposit has not been kept longer than is needful for the purposes of such business, and that the best available means have been taken to prevent injury or danger thereby to the public health.

The sub-section does apply, however, to deposits of ash-pit refuse deposited by a Local Authority under scavenging provisions, for which section 37 (2) of this

Act makes provision for dealing with a nuisance arising therefrom; it also deals with burning colliery-bings.]

(6) Any work, manufactory, trade, or business injurious to the health of the neighbourhood, or so conducted as to be injurious or dangerous to health, or any collection of rags or bones injurious or dangerous to health;

[Under this sub-section it is not enough to aver mere offensiveness; it will be necessary to aver and prove injury to health.

The section of the Act (section 36) which deals with any nuisance arising from offensive trades or businesses, is, perhaps, an equally, if not more, effective method of suppressing such nuisances. Nuisances due to effluvia from alkali and chemical works are controlled by the Alkali, etc., Works Regulation Act, 1881. In burghs power is given under section 316, B. (6) of the B. P. (Scot.) Act, 1892, to frame bye-laws for regulating the operation of noxious trades, and under section 316, B. (5) for regulating the keeping of depots of bones, carrion, rags, or any other offensive matter or thing.]

(7) Any house or part of a house so overcowded as to be injurious or dangerous to the health of the inmates;

[" House " is defined in section 3 of this Act as a " dwelling-house, and includes schools, also factories and other buildings in which persons are employed," and in section 177, a ship is held to be equivalent to a " house."

Overcrowding must have relation to cubic and superficial spaces. No such spaces are specified per individual in this Act, but a Local Authority have powers to establish such for common lodging-houses in section 92, in other lodging-houses in section 72, and in tents, vans, sheds, and other temporary structures in section 73. Statutory provision for the L. G. Board making regulations for such spaces is laid down in the Canal Boats Act, 1877 (which applies only to England), section 2, but any such regulations shall not come into force until they have been laid before Parliament.

Section 76 enacts further that where two convictions within *three months* have been obtained against any person for overcrowding a house, the Sheriff may order such house to be closed for such period of time as he may deem necessary.

When Part IV. of this Act (Prevention of Epidemic Disease) comes into force by special declaration of the L. G. Board, a Local Authority are empowered by section 84 to regulate the conditions of occupation of dwellings relative to overcrowding according to the provisions of the Act in reference to common lodging-houses.

In the Burgh Police (Scotland) Act, 1903, sections 64, 65, and 67 (which are *adoptive*) make provision for cubic spaces in dwellings of differing numbers of apartments.

In charges based on the above sub-section 7, the occupier must be proceeded against, and, as has been remarked, it is necessary to aver and to prove injury or danger to the health of the inmates of the house.]

(8) Any schoolhouse, or any factory which is not a factory subject to the provisions of the Factory and Workshop Acts, 1878 to 1895, or any Act amending the same (Act of 1901), with respect to cleanliness, ventilation, or overcrowding, and

(i) is not kept in a cleanly state and free from effluvia arising from any drain, privy, water-closet, earth-closet, urinal, or other nuisance, or

(ii) is not ventilated in such a manner as to render harmless so far as practicable any gases, vapours, dust, or other impurities generated in the course of the work carried on therein, that are a nuisance or injurious or dangerous to health, or

(iii) is so overcrowded while work is carried on as to be injurious or dangerous to the health of those therein employed;

[The Factory and Workshop Act, 1895, section 1 (i), declares that a workshop shall be deemed to be so overcrowded as to be dangerous or injurious to the health of those employed therein, if the amount of cubic space in any room therein bears to the number of persons employed at once in a room a proportion less than 250 cubic feet, or, during overtime, less than 400 cubic feet of space to every person.

Proviso (*b*) to section 16 of the P. H. (Scot.) Act, 1897, enacts that in considering whether any dwelling-house or part thereof which is also used as a factory, or whether any factory, used also as a dwelling-house, is a nuisance by reason of overcrowding, the Court shall have regard to the circumstances of such other use. (For the definitions of the expressions "factory" and "workshop," see pp. 557–8.)

Under the Cotton Cloth Factories (Amendment) Act, 1887, daily observations must be made respecting the amount of watery vapour contained in the atmosphere of the working-places.

Proviso (*b*), already given, applies to cases coming under this sub-section (iii).

The Factory and Workshops Act, 1901, declares that "*cleanliness*" is to be interpreted to mean in a cleanly state and free from effluvia, and "*ventilation*" to mean the existence or provision of such means for changing the air as to render harmless, so far as practicable, any gases, etc., which are a nuisance.

Proceedings under this sub-section must be founded upon—

(*a*) a certificate of the Medical Officer of Health, or

(*b*) representation by a Parish Council, or

(*c*) requisition in writing by ten ratepayers of the district of the Local Authority, and must be taken before a Sheriff.]

(**9**) Any fire-place or furnace situated within the limits of any burgh or special scavenging district which does not so far as practicable consume the smoke arising from the combustible matter used therein, for working engines by steam, in any mill, factory, dyehouse, brewery, bakehouse, or gaswork, or in any manufacturing or trade process whatsoever;

[For burghs of not less than 2000 inhabitants, the provisions of the Smoke Nuisance Abatement (Scotland) Act, 1857, and the Amending Acts of 1861 and 1865, apply, and under these Acts the Procurator-fiscal of the burgh initiates proceedings.

It is not necessary in cases under this sub-section to aver or to prove injury or danger to health.]

(**10**) Any chimney (not being the chimney of a private dwelling-house) sending forth smoke in such quantity as to be a nuisance or injurious or dangerous to health;

[In cases under this sub-section, the test will probably be—the quantity and the time of continuous issue of black smoke from the chimney. Such a test is, however, liable to be depreciated in value by the passing of spent steam into the works' chimney thus to dilute and to lighten the colour of the smoke which issues.]

(**11**) Any churchyard, cemetery, or place of sepulture so situated or so crowded or otherwise so conducted as to be offensive or injurious or dangerous to health, shall be deemed to be nuisances liable to be dealt with summarily in manner provided by this Act;

[In cases under this sub-section it is only necessary to prove offensiveness. Nor is it necessary to summon any individual person as the author of the nuisance, but intimation must be given to the collector of church-yard dues or other person directed by the Sheriff.

The proceedings to be conducted before the Sheriff are regulated by section 22 of this Act:—in cases under sub-section (11) in section 16, it shall not be necessary to cite any person as the author of the nuisance, but such application shall be proceeded with by the Sheriff (to whom alone it shall be made) after such intimation to the Collector of the church-yard or other dues, or to such other person as to the Sheriff shall seem meet; and such person or persons as shall appear after such intimation shall, if the Sheriff think proper, be allowed to be heard and to object to such application in the same manner as if he or they were the authors of the alleged nuisance within the meaning of this Act.

The Burial Grounds (Scotland) Act, 1855, provides an alternative procedure for closing a graveyard. By section 4 of this Act, it is enacted that any two members of a Parish Council, or ten ratepayers, or two householders who reside within 100 yards of an existent graveyard, may apply to the Sheriff for closure, who shall make inquiry, and if he finds that such graveyard is dangerous to health, or offensive, or contrary to decency, he shall pronounce accordingly by interlocutor, and shall transmit a copy of the same to the Secretary for Scotland: thereafter an Order in Council may be issued for closing the graveyard.

Like procedure is provided for the proposed establishment of a new graveyard.

Section 146 (2) of the P. H. (Scot.) Act, 1897, extends to Local Authorities power to initiate proceedings under the Burial Grounds Act.

If procedure be taken by a Local Authority under the Burial Grounds Act and thereby a graveyard is closed, it is incumbent on the Parish Council, under section 10 of that Act, to provide a new graveyard; if, on the other hand, procedure be taken under section 16 (11) of the P. H. (Scot.) Act, 1897, no such duty lies on the Parish Council, but, if the Parish Council thinks fit, it may provide a new burial ground under section 9 of the Burial Grounds Act.

There is no similar sub-section in the Public Health Act, 1875 (England), but the provision of new places of burial and the making of bye-laws concerning such, are met by the Public Health (Interments) Act, 1879. Model bye-laws on the sanitary requirements have been framed by the English Local Government Board.[1]]

Note.—While section 91 of the Public Health Act, 1875 (England), enumerates as statutory nuisances, with some differences in phraseology and matters included, those embraced in the foregoing sub-sections (1), (2), (4), (5), (7), (8), and (9), it omits, in addition to the above-noted exception, sub-section (11), the matters dealt with in sub-sections (3), (6), and (10).

Procedure under Section 16.

As soon as information of the existence of a nuisance is received

(*a*) the Sanitary Inspector or other officer (section 19) forthwith sends *intimation* of the existence of the nuisance to the author of the same;

(*b*) if the nuisance is not removed, a *notice* is then served on the author calling upon him to remove the nuisance within the time specified in the notice, and to do such necessary works and things as will remove the nuisance (section 20). Certification of the service of such notice to be proved and attested by a witness (section 159);

(*c*) if nuisance is not removed within the time specified, or if removed is likely to recur, the Local Authority shall apply to the Sheriff by summary petition (sections 21 and 22);

(*d*) the Sheriff then orders the petition to be served on the author of the nuisance, or, failing him, on the owner or occupier of the premises in which the nuisance exists, and appoints a day for answers to be lodged or for hearing parties (section 154);

(*e*) the Sheriff, on considering answers, or on hearing parties, or if the defendant fail to appear, may at once decern (section 154); or he may remit to a man of skill to report, and may decern on said report; or, if either party desire it, he may allow a proof (section 154). No written pleadings are allowed. The Sheriff, in cases under the sub-sections (9), (10), and (11) of section 16, must take notes of the evidence as in civil proofs (section 165);

(*f*) if the Sheriff finds the averments proved, he shall order removal of the nuisance, specifying such works to be done as he may deem necessary, which need not be confined or limited to any special remedy asked for in the petition (sections 22 and 23); or, if he considers that the nuisance is likely to recur, he may also grant interdict; or, should structural works be required, he may direct these to be carried out under direction of a person whom he shall appoint and name, and may require the Local Authority to furnish him with an estimate of the cost (section 25);

(*g*) if the Sheriff finds that the nuisance arose from the wilful fault or culpable negligence of either owner or occupier of the premises, he may impose a fine not exceeding £5 ;

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[1] Report of L. G. Board, 1882, App. p. 7.

(*h*) if the defender fails to implement the decree, or should infringe the interdict, he becomes liable to penalties (section 24), and the Local Authority may apply for a warrant to have the nuisance removed at defender's expense (section 26) ;

(*i*) when the author of the nuisance is not known, or cannot be found, the Sheriff has power to ordain the Local Authority to execute the necessary works (section 26) ;

(*j*) the judgment of the Sheriff shall be final (section 157), except in cases under sub-sections (9), (10), and (11), when certified in terms of section 156, in which case appeal to the Lord-Ordinary is allowable.

As has already been pointed out, the Public Health (Scotland) Act, 1897, section 17, makes it obligatory on Local Authorities to cause inspection of their districts to be made from time to time for the purpose of enforcing the removal of nuisances when found, and otherwise to put in force the powers vested in them relating to public health, so as to secure the proper sanitary condition of all premises within their districts.

Law as to Offensive Trades

The Public Health (Scotland) Act, 1897, sections 32 to 37 inclusive, deals with offensive trades.

The trades mentioned in section 32 are as follow :—

1. Blood boiler.
2. Bone boiler.
3. Manure manufacturer.
4. Soap boiler.
5. Tallow melter.
6. Knacker.
7. Tanner.
8. Tripe boiler.
9. Gut or tripe cleaner.
10. Skinner or hide-factor.
11. Slaughterer of cattle or horses.
12. Or, any other business which the Local Authority may declare by order confirmed by the Local Government Board and published in the *Edinburgh Gazette* to be an offensive business.

The provisions contained in the above-named sections may be paraphrased as follows :—

If any person, without the sanction of the Local Authority, establishes the fore-mentioned businesses, or any of them, he shall be liable to a fine not exceeding £50, and any person carrying on the same after conviction of that offence, to a penalty not exceeding £25 for every day during which he so carries on the same. The Local Authority are to give their sanction by order. But fourteen days at least before doing so, the Local Authority shall make public the application by advertisement in one or more local newspapers or by posting handbills in the locality, setting forth a time and place at which they should be willing to hear all persons objecting, shall consider such objections, and shall grant or withhold their sanction as they shall think it expedient. When the Local Authority grant or withhold such sanction, any person aggrieved may appeal to the Local Government Board, whose decision shall be final ; but in a district other than a burgh, the appeal to the Board shall only arise after the County Council has given its determination on the matter, and a Local Authority may appeal to the Board against the determination of the County Council.

A Local Authority may make bye-laws for *regulating the conduct* of any businesses within the meaning of this section (32) and of section 37 of this Act, which are for the time being lawfully carried on in their district, and the *structure of the premises* of such businesses in order to prevent or diminish the noxious or injurious effect thereof, and the *mode in which applications for sanction are to be made.* Any such bye-law may, in addition to any pecuniary penalty imposed therein, empower a Sheriff by summary order to deprive any person, either temporarily or permanently, of the right of carrying on any business to which the bye-law relates, as a punishment for infringing the same. Disobedience to such order shall involve a penalty not exceeding £25 for every day during which the disobedience shall continue. The decision of the Sheriff may be appealed to the Lord-Ordinary (section 156).

For any order by a Local Authority to establish any such offensive business a fee, not exceeding forty shillings, as the Local Authority may fix, shall be charged.

For the purposes of this section, a business shall be deemed to be established after the commencement of this Act, not only if it is established newly, but also if it is removed from any one set of premises to any other premises, or if it is renewed on the same set of premises after having been discontinued for twelve months or more, or if any premises are enlarged without the sanction of the Local Authority. But a business shall not be deemed to be established anew on any premises by reason only of any change of ownership or occupancy of such premises, or that the building has been wholly or partially pulled down or burned down and has been reconstructed without any extension of area.

Licensing of Slaughter-houses.

Any person carrying on the business of a slaughterer of cattle or horses, or of a knacker, shall not use any premises for that purpose without a license from the Local Authority, under a penalty of not more than £5. The fact that cattle or horses have been taken into unlicensed premises shall be *prima facie* evidence that an offence under this section (section 33) has been committed. Every such licence shall expire on such day in every year as the Local Authority shall fix, and no matter at what intermediate time of year any such licence is so granted it shall expire on such appointed day, which secondly follows the date of grant; thus a licence granted in January 1911 will remain in force until the day appointed in 1912, and not that in 1911. A fee of not more than 5s. may be charged for such licence or renewal of the same. Not less than twenty-one days before any new licence for any new premises is granted, notice of the intention to apply for it shall be advertised as is provided for in section 32 (2), by the Local Authority, and any person interested may show cause against such grant or renewal. Any objection shall not be entertained unless seven days' previous notice of the same has been served on the applicant, with the exception that where an objection has been made of which notice has not been given, the Local Authority, if they think fit, may direct notice thereof to be served on the applicant, and may adjourn the question of renewal to a future day and require the attendance of the applicant on that day, and then hear the case and consider the objection as if such notice had been duly given. A licence shall be deemed to be renewed when a further licence is granted in immediate succession to a prior licence for the same premises.

The Local Authority shall have the right to enter any slaughter-house or knacker's yard at any hour by day, or at any hour while business is going on, for the purpose of examining whether or not there is any contravention of the Act or of any bye-law.

Where a person carrying on a slaughterer's or knacker's business has been refused a renewal of licence, such person may appeal to the Local Government Board, and the decision of the Board shall be final, but in the case of a district other than a burgh, the appeal shall only arise after the County Council has determined the question, and a Local Authority may appeal against a determination of a County Council. (Section 33.)

The expression "*slaughterer of cattle or horses*" means a person whose business it is to kill any description of the cattle or horse kind for the purpose of the flesh being used as butcher's meat; the expression "*slaughter-house*," any building or place used for such business; the expression "*knacker*," a person whose business it is to kill any animal of the cattle or horse kind, not killed for the purpose of the flesh being used as butcher's meat; and the expression "*knacker's yard*," any building or place used for such business. (Section 3.)

A Local Authority of any district other than a burgh may provide, establish, improve, or extend and maintain *within* or *without* their district, and two or more Local Authorities may combine so to do, fit shambles or slaughter-houses for the purpose of slaughtering cattle, and may borrow moneys for that purpose. (Section 34.)

Upon receipt of a certificate of the Medical Officer of Health, or a representation of a Parish Council, or a requisition in writing by ten ratepayers within their district, to the effect that any trade, business, etc., carried on in any building and causing effluvia, is a nuisance or injurious or dangerous to the health of any of the inhabitants of the district, a Local Authority may, if they think proper, and if required by the L. G. Board shall, apply to the Sheriff by summary petition, and, if it appear to such Sheriff that such trade, etc., is causing a nuisance or any effluvia which is a nuisance or injurious or dangerous to the health of those in the district, then, unless it is shown that the best practicable means have been used for removing, or preventing, or counteracting the effluvia, the author of the nuisance, failing him the occupier, and failing him the owner of the premises, shall be liable to a penalty of not more than £50; provided that the Court may suspend judgment on condition that the offender undertakes, within a reasonable time, to adopt means for removing the nuisance, or mitigating or preventing the injurious or dangerous effects of the effluvia.

The Local Authority may cause proceedings to be taken in the Court of Session.

The Local Authority under this section (section 36) may take proceedings in respect of any manufactory or premises situated *without* their district, the proceedings to be taken before the Sheriff of the district *within* which such manufactory, etc., is situated.

The following are the bye-laws enacted within the city of Glasgow, in terms of section 32 (3), with respect to the business of manure manufacturer. Although similar bye-laws have been made for each of the other offensive trades named in that section (1), with the necessary changes consequent upon the differences in the business, those now to be given may be taken as an example of such bye-laws.

Public Health (Scotland) Act, 1897

The Corporation of the City of Glasgow, being the Local Authority of the said city under the Public Health (Scotland) Act, 1897, and having, under section 14 of the said Act, appointed the Committee on Health, being, as provided for in said Act, a Committee of their own body, to receive and issue notices, to take proceedings, and in all respects to execute Part II. of said Act, excepting sections 38, 39, and 41 of said Part II., the said Committee hereby make the following bye-laws under section 32 (3) for regulating (1) the conduct of the following business; (2) the structure of the premises in which any such business is being carried on, in order to prevent or diminish the noxious or injurious effect thereof; and (3) the application to be made to the said Committee for sanction for carrying on such business:—

BYE-LAWS FOR THE BUSINESS OF MANURE MANUFACTURER

I.—The Conduct of the Business

Offensive effluvia during storage.

1. Every manure manufacturer shall cause all material, manufactured product, residue, refuse, or other matter used on or in connection with the

premises where his business is carried on, from which any offensive effluvium, vapour, or gas may be evolved, to be received or stored in rooms, chambers, or places constructed in such a manner as to prevent any such effluvium, vapour, or gas escaping into the external air.

2. Every manure manufacturer shall cause every process of his business in which any offensive effluvium, vapour, or gas is generated to be carried on in such manner that no offensive effluvium, vapour, or gas shall escape into the external air; and he shall cause all such offensive effluvium, vapour, or gas to be effectually destroyed. Offensive effluvia during manufacture.

3. Every manure manufacturer shall cause the floors, walls, and ceilings of premises in which his business is carried on to be kept thoroughly clean and in good repair. He shall cause all the floors (except those of the packing-rooms and offices) to be thoroughly cleansed and flushed with water at least once in each twenty-four hours, and shall cause every internal wall or part of a wall which is not perfectly smooth and hard on the surface, and every ceiling, to be washed with hot lime in each of the months of January, April, July, and October in each year. Cleanliness of floors, walls, etc.

4. Every manure manufacturer shall cause every vehicle, vessel, utensil, or instrument provided or used in connection with his business to be kept thoroughly clean. Utensils.

5. Every manure manufacturer who grinds and mixes manure by machinery shall, in the apartment where this work is carried on, provide for mechanical or other means of ventilation to the satisfaction of the Local Authority. Grinding or mixing rooms to be ventilated.

6. Every manure manufacturer shall cause the drains in connection with his premises to be thoroughly flushed out with water when necessary, or at any time if required by the Local Authority or their officers. He shall also cause to be emptied at such times as the nature of his business demands, or as the Local Authority may require, any cesspool or catchpit provided in terms of No. 9A of these bye-laws. Drainage.

7. Every manure manufacturer shall arrange that all refuse matter is removed every twenty-four hours by the Cleansing Department, or shall cause it to be otherwise so disposed of as not to create a nuisance. Refuse removal.

8. Every manure manufacturer shall afford free access to every part of his premises to the Medical Officer of Health, the Sanitary Inspector, or any assistant bearing an official warrant card, at any time during the hours within which the business is being carried on. Access.

II.—The Structure of Premises

9. Every manure manufacturer shall cause the walls of every building within which any part of his business is carried on to be built with stone, brick, or other equally solid and impervious material, and shall cause every floor therein (except those of the packing-room and offices) to be properly covered with asphalte, concrete, or other suitable impervious and jointless material, which in the case of the ground-floor shall be laid on a suitable bottom of at least six inches in thickness, and shall have a proper slope towards a channel or gully leading to the drainage system required by bye-law 6 hereof. All the walls, but those in the rooms above excepted, shall be faced inside to a height of at least six feet from the floors with tiles, glazed bricks, or other equally hard, smooth, and impervious material. Walls and floors.

9A. Every manure manufacturer shall cause all parts of his premises to be suitably drained, and shall connect the drains thereof with a common sewer, and shall, if required by the Local Authority, provide a cesspool so situated and constructed as to prevent solid matter finding access to the sewer, and so ventilated that offensive effluvia therefrom shall not escape so as to cause a nuisance. Cesspool.

10. Every manure manufacturer shall, when required by the Local Authority, cause the yards, courts, or areas, or any part thereof within the premises, to be properly bottomed to a depth of at least six inches with concrete or other solid Paving yards.

and substantial material, and thereafter paved with such jointless and impervious material as asphalte or concrete, or with granite or whin setts grouted with cement, having proper gradients towards a channel or gully to run off liquid matter to a suitable cesspool.

Chimney-stalk.

11. Every manure manufacturer shall cause the premises to be provided with a chimney-stalk of such height and area in cross section as the Local Authority may require.

Effluvium from premises.

12. Every manure manufacturer shall cause every room, chamber, or other place which may be used on or in connection with the premises where his business is carried on for the purpose of receiving, treating, or storing any material, manufactured product, residue, or other matter from which any steam, offensive effluvium, vapour, or gas may be evolved, to be furnished with suitable appliances, so constructed and used as to effectually prevent any such steam, effluvium, vapour, or gas from escaping into the external air, and shall cause all such steam, effluvium, vapour, or gas to be destroyed.

Effluvium from apparatus.

13. Every manure manufacturer shall provide his boilers, digesters, condensers, or other apparatus in which any steam, offensive effluvium, vapour, or gas may be generated, with suitable appliances for conveying said steam, effluvium, vapour, or gas towards a furnace or a condensing tower, or towards a condensing tower and then a furnace, or for so otherwise treating it as to effectually destroy it.

Water-supply.

14. Every manure manufacturer shall provide his premises with a plentiful supply of pure water at convenient places, and wherever required by the Local Authority.

Repairs and alterations.

15. Every manure manufacturer shall cause all needful repairs to the premises to be forthwith done and executed as and when the same shall become requisite, and shall cause such works and alterations to be made on the premises as may be required and deemed necessary by the Local Authority.

III.—APPLICATION FOR SANCTION TO CARRY ON SUCH BUSINESS

Plans to accompany application.

16. Every person who shall apply for sanction to carry on the business of manure manufacturer shall prepare and submit with his application—(1) a plan and sections, to a scale of not less than one-eighth of an inch to the foot, of the building or premises in which he proposes to carry on the same, showing the provision made, or proposed to be made, for the proper conduct of such business, and for the drainage, ventilation, and water-supply of such premises: (2) a survey plan of the locality, showing the streets, buildings, and inhabited houses within a radius of 100 yards of his proposed premises, drawn to a scale of not less than six inches to the mile; (3) a general explanation of the business, trade, or manufacture to be carried on, and of the raw materials, processes, and the product thereof; (4) a description, with drawings, if necessary, of the means proposed to be adopted to prevent nuisance arising from (*a*) vapours, (*b*) fluids discharged into sewers, and (*c*) the disposal of solid refuse; and (5) any further plans which may be required by the Local Authority.

IV.—PENALTIES

Penalty for infringement of Bye-laws.

17. Every person who shall not comply with any of the foregoing bye-laws shall be guilty of an offence, and shall be liable for such offence to a penalty not exceeding the sum of five pounds, and, in the case of a continuing offence, to a further penalty not exceeding forty shillings for each day after written notice of the offence from the Local Authority.

Deprivation of license.

18. Every manure manufacturer may, in addition to incurring the penalty or penalties imposed by the foregoing bye-laws, be, by summary order of the Sheriff (which he is hereby empowered to issue), deprived, either temporarily

or permanently, of the right of carrying on his business, and any manure manufacturer disobeying such order shall be liable to a penalty not exceeding twenty-five pounds for every day during which such disobedience continues: provided always, that the decision of the Sheriff shall be appealable to the Lord-Ordinary on the Bills, in the manner provided by section 156 of the Public Health (Scotland) Act, 1897.

Signed, under the Common Seal, by us, two members, and the clerk to the said Committee, on behalf of, and as authorised by, the said Committee, at Glasgow, the 18th day of January, 1899.

(*Here follow signatures*)

EDINBURGH, 12*th December* 1899.—Confirmed by the Local Government Board for Scotland.

Bye-Laws

According to Lumley "a bye-law is a law made with due legal obligation by some authority less than the Sovereign and Parliament in respect of a matter especially or impliedly referred to that authority and not provided for by the general law of the land."

A bye-law ought to be (1) *certain in its enactments*, free from ambiguity in language and meaning, and able to give complete direction to those who are to obey it; (2) *general in its application*; (3) *reasonable in fulfilment*; (4) *positive in its terms*; (5) *prescribe a definite penalty for breach of it*, as sanctioned by authority; (6) *must not be ultra vires*; that is, must be made in respect of a matter competent to the authority of the body enacting it, and operative upon persons within the jurisdiction of the enacting authority.

The Scottish Local Government Board recommend [1] that bye-laws should be strictly limited by the terms of the statute from which their authority is derived, the precise terms of the statute authorising them should be quoted, and where a section of a statute, authorising bye-laws for any purpose, specifies in detail the matter with which they have to deal, the bye-laws should be grouped under the corresponding subdivision of the section, and the words of the section should be quoted as to heading to each group; thus under section 72 and section 181 of the Public Health (Scotland) Act, 1897, the bye-laws should be grouped under the various sub-heads (*a*) (*b*), (*c*), of these sections, and the statutory words relating to these sub-heads should form the headings of the different groups. So, in like manner, should bye-laws be made under section 32 (3), thus:

(*a*) The conduct of the business (offensive businesses).
(*b*) The structure of the premises
} Under the limitation "in order to prevent or diminish the noxious or injurious effect thereof."

(*c*) The mode of application for sanction to Local Authority.

Section 35 gives another example of definitely enumerated purposes with a limitation.

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[1] Public Health (Scotland) Act, 1897. Instructions, Forms, etc., 1903, p. 11.

Bye-laws as to pig-styes.

(1) The construction of pig-styes. (2) Places in which they may be erected. (3) Mode of cleansing at proper intervals.	Under the limitation "so as to prevent them from becoming a nuisance or dangerous to public health."

In framing bye-laws under section 181, sub-section (1) (*e*) the various matters therein mentioned should be dealt with separately, and the terminology and order of the words of the statute should be observed.

Provisions as to Buildings.—Bye-laws for—

(*a*) Construction of drains and arrangement of drainage of houses and buildings;
(*b*) Construction and arrangement of soil-pipes and waste-pipes;
(*c*) Construction and position of water-closets, earth-closets, privies, ash-pits, cesspools, dungsteads, slop-sinks, and rain-water pipes and rhones;
(*d*) Structure of walls, foundations, roofs, and chimneys, "*so far as likely to affect human health*";
(*e*) Sufficiency of space about buildings, "*to ensure a free circulation of air*";
(*f*) Ventilation of houses and buildings;
(*g*) Production and inspection of suitable building-plans;
(*h*) Intimation to Local Authority previous to commencement of work, for inspection of work in process of erection or alteration, for examination of drains, and for the pulling down, alteration, or amendment of any work carried out in contravention of the bye-laws.

Authentication of Bye-laws.—All bye-laws made by a Local Authority under and for the purposes of the Public Health (Scotland) Act shall be under their common seal, or if they have no common seal, shall be signed by two members and the clerk of such Authority. Any such bye-law may be altered or repealed by a subsequent bye-law duly made. But no bye-law under the Act by any Local Authority shall be of any effect if repugnant to the law of Scotland or to the provisions of the Act. (Section 183, P. H. (Scotland) Act, 1897; Section 182, Public Health Act, 1875.)

A Local Authority may, by any bye-laws made by them, impose on offenders against such bye-laws such reasonable penalties as they think fit, but never to exceed £5, and in the case of a continuing offence, a further penalty not more than 40s. for each day after written notice of the offence from the Local Authority; but all such bye-laws imposing any penalty shall be so framed as to allow of the recovery of any sum less than the full penalty, and in no case shall greater penalties than those named be imposed. (Section 184, P. H. (Scot.) Act, 1879; Section 183, P. H. Act, 1875.)

Confirmation of Bye-laws.—Bye-laws made by a Local Authority shall not take effect unless and until they have been submitted to and confirmed by the Local Government Board, who are empowered to allow, modify, or disallow the same as the Board may think proper. Nor shall any such bye-laws be confirmed—unless notice of intimation to apply for confirmation of the same has been given in one or more local newspapers circulated within, or by handbills posted throughout the district to which such bye-laws relate, one month at least before the application is made; and unless for one month at least before the application is considered, a copy of the proposed bye-laws has been kept in the office of the Local Authority, and, in the case of districts other than burghs, at the office of the Parish Council of every parish to which such bye-laws relate, and has been open during office hours thereat to the inspection of the ratepayers of the district without fee or reward. Any person aggrieved by any proposed new bye-law or by any proposed alteration of any existing bye-law may within that month forward notice of his objection to the Board, who shall consider the same before granting confirmation. If any such ratepayer applies, the clerk of the Local Authority shall furnish him with a copy of such proposed bye-laws or any part of the same on payment of sixpence for every hundred words contained in such copy.

A bye-law when confirmed by the Local Government Board shall not require confirmation, allowance, or approval of any other authority. (Section 185, P. H. (Scot.) Act, 1897; Section 184, P. H. Act, 1875.)

Printing of Bye-laws.—All bye-laws made by a Local Authority (1) shall be printed and hung up in the office of such authority; (2) shall be open to inspection of any ratepayer of the district at all reasonable hours; (3) and a copy thereof shall be delivered to any ratepayer on his application for the same. Where bye-laws are made by a District Committee, a copy shall be sent to the Parish Council of every parish to which such bye-laws relate, to be deposited with the public documents of the parish, and to be open to inspection, and to be delivered as above. (Section 186, P. H. (Scot.) Act, 1897; Section 185, P. H. Act, 1875.)

Evidence of Bye-laws.—A duly signed and certified copy of any bye-laws made in pursuance of this Act shall be evidence, until the contrary is proved, in all legal proceedings of the due making, confirmation, and existence of such bye-laws without further or other proof. (Section 187, P. H. (Scot.) Act, 1897; Section 186, P. H. Act, 1875.)

Provision as to the Regulations of Local Authority.—The provisions of this Act relating to bye-laws shall not apply to any regulations which a Local Authority is by this Act authorised to make; nevertheless any Local Authority may cause any *regulations* made by them under this Act to be published in such manner as they see fit. (Section 188, P. H. (Scot.) Act, 1897; Section 188, P. H. Act, 1875.)

A Local Authority under the P. H. (Scot.) Act, 1897, is empowered to make such regulations with reference to the following matters:—(*a*) duties of medical officers and sanitary inspector and their relations to each other (section 15); (*b*) respecting information as to nuisances by police constables or officers (section 19); (*c*) management of mortuaries (section 70); and (*d*) communications between drains and sewers.

Bye-laws which may be made by Local Authorities

I. **County Council.**—"For the prevention and suppression of nuisances not already punishable in a summary manner by virtue of any Act in force throughout the county." (Local Gov. (Scot.) Act, 1889, section 57.)

II. **Burgh Commissioners.**—For enforcing provisions of sections 107–126 with reference to cleansing. (Burgh Police (Scot.) Act, 1892, Section 127.)

For regulating all matters connected with water supplied within the burgh through their pipes. (*Ibid.*, Section 268.)

For licensing, registering, regulation and inspection of slaughter-houses, preventing cruelty therein, and for keeping the same in a cleanly and proper state. (*Ibid.*, Section 281.)

1. *For General Purposes.* (*Ibid.*, Section 316):

(*a*) Preventing nuisances and annoyances in any street;

(*b*) Controlling persons buying or selling old clothes;

(*c*) Preserving and regulating public bleaching-greens, public wash-houses, baths, gymnasiums, public parks and open spaces, and preventing offences, nuisances, and annoyances therein;

(*d*) For fixing the times of lighting and extinguishing lights in common stairs and private courts and the order or rotation in which occupiers of houses or flats in common stairs, etc., shall be responsible for doing such duties;

(*e*) Regulating the beating and shaking of carpets, etc., in streets, courts and open spaces held in common, and the hours within which such work may be done;

(*f*) Regulating the fencing, pulling down, clearing out, and securing of ruinous or unclaimed lands or heritages;

(*g*) Regulating the driving of cattle through the streets, and prescribing through what streets and at what hours cattle may be driven;

(*h*) For the better preservation of any common, links, bleaching-green, recreation-ground, open area or space, or other places of public resort or recreation, regulating the use of the same and for ensuring good order therein;

(*i*) For providing that drift logs of wood are secured by the owners;

(*j*) For carrying out or enforcing any other provisions of the Act not herein specially mentioned.

2. *For Sanitary Purposes*:

(*a*) For inspecting all places where horses are killed and carrion is kept or sold, keeping such places in a cleanly and proper state, removing filth therefrom, and requiring provision of proper paving, drainage, and water-supply;

(*b*) For removing the contents of ash-pits, dungsteads, or other receptacles of foul matters within reasonable periods, preventing foul water soaking from any building, and preventing any ash-pit, etc., from being a nuisance or annoyance;

(*c*) For inspection and periodical cleansing of cisterns used in common by two or more families;

(*d*) Regulating the time and mode of removal of any offensive matter or thing;

(*e*) Regulating the keeping of depôts of bones, carrion, rags, or any other offensive matter or thing;

(*f*) Reducing or removing the noxious or injurious effects attending the business of any noxious or offensive business, trade, or manufacture;

(*g*) For providing that cattle, dogs, and poultry shall not be kept in such places or in such manner as to be a nuisance or annoyance to inhabitants, for prescribing the places in which swine may be kept, and for prohibiting, on cause shown, the keeping of swine;

(*h*) For requiring owners or occupiers of houses and buildings to keep clean all places and thoroughfares owned or occupied by them, and for paving private courts, common passages, and common areas;

(*i*) For regulating, sweeping, and cleansing of common stairs;

(*j*) For carrying out the provisions of sections 238 to 256 (*vide* p. 325 to p. 328), both inclusive.

III. **Local Authorities Generally.**—Under limitation of:

1. *Offensive Businesses*:

Bye-laws for regulating (*a*) the conduct of any businesses within the meaning of sections 32 and 37 [P. H. (Scot.) Act, 1897], (*b*) the structure of the premises, and (*c*) the mode in which application for sanction to establish is to be made (sub-section 2, section 32).

"In order to prevent or diminish the noxious or injurious effect thereof."

Note.—The following are offensive businesses within the meaning of these sections: Blood-boiler, bone-boiler, manure manufacturer, soap-boiler, tallow-melter, knacker, tanner, tripe-boiler, gut- or tripe-cleaner, skinner or hide-factor, slaughterer of cattle or horses.

2. *Pig-Styes.* [P. H. (Scot.) Act, 1897, sect. 35]:

To regulate (*a*) Construction of pig-styes, (*b*) places in which they may be erected, and (*c*) mode of cleansing them at proper intervals.

"So as to prevent them from becoming a nuisance or dangerous to public health."

3. *Removal of House Refuse and Street Refuse.* [*Ibid.*, Sect. 32, (3); Sect. 37, (1)]:

To regulate (1) the conduct of the business, and (2) the structure of the premises in which the business is carried on.

"In order to prevent the noxious or injurious effect thereof."

4. *Public Conveyances.* [*Ibid.*, Section 65]:

Bye-laws for (1) securing the cleanliness and sanitary condition of public conveyances plying within the district, and (2) preventing overcrowding in the same.

5. *Mortuaries.* [*Ibid.*, Section 68]:

Bye-laws (1) with respect to the management, and (2) with respect to charges for the use of such mortuaries as they may provide and fit up.

6.—*Houses Let in Lodgings.* [*Ibid.*, Section 72]:

Every Local Authority may, and if required by the L. G. Board shall, make and enforce for the whole or any part of their district such bye-laws as are requisite for the following matters—viz.

(1) For fixing the number of persons who may occupy a house or part of a house which is let in lodgings or occupied by members of more than one family;

(2) For the registration of houses so let or occupied;

(3) For the inspection of such houses;

(4) For enforcing sufficient privy or w.c. accommodation and other appliances and means of cleanliness in proportion to number of lodgers or occupiers, drainage for such houses, for promoting

cleanliness and ventilation in such houses, and for the cleansing and ventilation of the common passages and staircases;

(5) For cleansing and whitewashing of the premises at stated times;

(6) For giving of notices and the taking of precautions in case of any infectious disease.

Note.—Where such bye-laws under section 72 are to apply only to a *part of a district*, it will be necessary to specify, either in the bye-laws themselves or in the advertisement required by section 185, the part of the district to which they are confined.

7. *Tents and Vans used for Human Habitation.* [*Ibid.*, Section 73, (2)]:

(1) For promoting cleanliness in, and habitable condition of tents, vans, sheds, and similar structures used for human habitation;

(2) For preventing spread of infectious diseases by persons inhabiting the same; and

(3) For preventing nuisances in connection with the same.

8. *Common Lodging-Houses.* [*Ibid.*, Section 92.] For—

(1) The keeping and well-ordering of such houses;

(2) The separation of the sexes therein;

(3) Fixing the number of lodgers in each house and in each room;

(4) Enforcing sufficient privy or w.c. accommodation and other appliances and means of cleanliness in proportion to number of lodgers and occupiers;

(5) Enforcing proper drainage and ash-pits for such houses;

(6) Promoting cleanliness and ventilation for such houses;

(7) Inspection of houses, and the conditions and restrictions under which inspection may be made.

Note.—Copy of said bye-laws, when confirmed and printed, to be furnished gratis to every keeper of such house, and such keeper shall be bound to keep a copy thereof hung up in some conspicuous place in each room in which lodgers are received. (Section 93.)

Contravention of these bye-laws may be prosecuted before any judge or magistrate having police jurisdiction, and in the same way and manner as police offences are tried before him under any general or local Police Act. (Section 153.)

9. *Removal to Hospital of Sick Persons brought by Ship.* [*Ibid.*, Section 180]:

(1) For removal to hospital of such patients;

(2) For keeping in hospital so long as may be necessary any persons brought by ship who are infected with an infectious disease.

10. *Provisions as to Buildings—Building Regulations.* [*Ibid.*, Section 181.]

The Local Authority of any district, *other than a burgh*, may, subject to the approval of the County Council, make bye-laws for the whole or any part of their district for—

Regulating the building or rebuilding of houses or buildings, or the use for human habitation of any building not previously so used, or any alteration in the mode of occupancy of any existing house in such a manner as will increase the number of separate houses, in respect of the following matters:—

(1) Construction of drains of subsoil of sites to prevent dampness in houses intended for human habitation;

(2) Structure of walls, foundations, roofs, and chimneys of new buildings;

"In so far as likely to affect human health."

(3) Ventilation of houses and buildings intended for human habitation;

(4) Sufficiency of space about buildings;

"To secure a free circulation of air."

(5) Construction and arrangement of the drainage of houses and buildings, and of soil-pipes, and waste-pipes, and the position and construction of water-closets, earth-closets, privies, ash-pits, cesspools, dungsteads, slop-sinks, and rain-water pipes and rhones;

(6) Production of suitable building-plans in respect of the matters in this section mentioned, and their inspection;

(7) Intimation previous to commencement by owner or person laying out the work to the Local Authority of date of commencement, and for due inspection in respect of the matters mentioned in this section concerning houses or buildings in process of erection or alteration, and the examination of the drains thereof, and for the pulling down, alteration, or amendment of any work done in contravention of the bye-laws.

Note.—In burghs, these matters are regulated by the rules for new buildings which are laid down in Schedule IV. of the Burgh Police (Scotland) Act, 1892, which rules, however, may be altered by the Commissioners with approval of the Sheriff. (Section 177.)

Regulations

Throughout the Public Health (Scotland) Act, 1897, mention is occasionally made of *regulations* which may be made by different authorities respecting various matters.

Section 15, for example, enacts that a Local Authority, with the approval of the L. G. Board, shall regulate the duties of the M. O. H. and S. I., and their relations to each other (p. 19); section 19, that it shall be the duty of a Local Authority to make regulations respecting the duty of every officer of such Authority and of any constable or officer of police to give information of any nuisance under the Act; section 60 (10), with respect to inspection of dairies, etc., that nothing in that section shall interfere with the operation or effect of the Contagious Diseases (Animals) Acts, 1878 to 1886, or of any regulation, licence, or act of a Local Authority, made, granted, or done under any order of the Privy Council; section 66 (4), that a L. A., with the sanction of and subject to regulations made by the L. G. Board, may provide portable hospitals (p. 510); section 70 (1), that a L. A. may make regulations with respect to the management of any proper building they may erect for post-mortem examinations (p. 480); section 78 81 (Part IV., Prevention of Epidemic Diseases), that the L. G. Board may from time to time make such regulations as to the Board may seem fit regarding the spread of such diseases; and section 110, that a L. A. have power to make regulations with regard to drainage connections (p. 316). Regulations differ from bye-laws. According to section 188 of the Act, provisions in the Act relating to bye-laws shall not apply to any regulations which a Local Authority are by the Act authorised to make; nevertheless, a Local Authority may cause any regulations made by them under the Act to be published in such manner as they may see fit.

Regulations, therefore, in contradistinction to bye-laws, may be defined to be such rules laid down by a Local Authority in respect of matters authorised by statute as do not require the sanction of the L. G. Board, but which may be published by the Local Authority in such manner as they may think fit.

Regulations made by a Local Authority under the Dairies, Cowsheds, and Milk-shops Orders of 1885, 1887, and 1899, must, however, be confirmed by the L. G. Board.

CHAPTER XVII

LAW RELATING TO SALE OF FOOD

With respect to Unsoundness.

(A) In Scotland.

Public Health (Scotland) Act, 1897. Section 43.

Any medical officer, or sanitary inspector, or any veterinary surgeon approved for the purposes of this section by the Local Authority may at all reasonable times enter any premises within the district of the Local Authority or search any vehicle, barrow, basket, sack, bag, or parcel in order to inspect or examine and may inspect and examine—

(*a*) any animal, alive or dead, intended for the food of man which is exposed for sale, or deposited or being transmitted for sale or preparation for sale ; and

(*b*) any article, solid or liquid, intended for the food of man, etc.

—the proof that the same was not exposed or deposited or being transmitted for any such purpose to rest upon the person charged. And if any such animal or article appears to any such officer to be diseased or unsound or unfit for the food of man, he may by himself or an assistant seize and carry away the same, in order that it may be dealt with summarily by the Sheriff, magistrate, or justice.

Provided that in the case of a living animal, the medical officer of health or sanitary inspector (unless he himself is a qualified veterinary surgeon) shall be accompanied by a veterinary surgeon.

The police shall have power to search vehicles, etc., and shall assist in executing or enforcing this section.

If it appears to a Sheriff, etc., that any such animal or article so seized is diseased, or unsound, or unfit for the food of man, he shall condemn the same and order it to be destroyed, or so disposed of as to prevent it being exposed for sale or used for the food of man ; and the person, if found guilty, shall be liable to a penalty not exceeding £50 for every animal or article.

If the article consists of fruit, vegetables, corn, bread, or flour, unless he proves that he or anyone acting for him did not know, and could not with reasonable care have known, that it was unsound, etc., and unfit for human food, he shall be liable to a like penalty. Should, however, in proceedings before the Sheriff, it be found in evidence that such person knowingly and wilfully committed the offence, he shall be liable to imprisonment with or without hard labour, and to pay all expenses relating to seizure, detention, or disposal of the article. Should the person prove that the animal or part thereof condemned was within a reasonable time prior to the seizure examined where it was slaughtered and passed by a veterinary surgeon, he shall be exempt from penalty or imprisonment.

Each Local Authority, or two or more Local Authorities in combination, may appoint a place or places within the district or their districts, and may fix a time or times at which a veterinary surgeon approved by them shall attend for the purpose of examining any animal alive or dead which may be there submitted to him, and of passing or condemning the animal, and such veterinary surgeon shall, on receipt of a fee to be fixed by the said Local Authority or Authorities and paid by the owner, examine and pass or condemn in whole or in part any animal or carcase submitted to him. If he passes the same, he shall grant a certificate to that effect, setting forth therein name of owner, date and hour of examination, and such other particulars as the Local Authority or Authorities may prescribe. If he condemn the animal or carcase or part thereof, the animal or carcase or part condemned shall be retained and forthwith destroyed by the Local Authority, or so disposed of as to prevent the same being exposed for sale or used for the food of man, the owner to be entitled to the net price realised from the residual product of the carcase or part condemned, after deduction of any expenses.

No carcase shall be submitted for such examination unless as a whole carcase, and including the thoracic and abdominal viscera, so that the examiner may satisfy himself that the organs shown are those of the carcase submitted for examination.

Where it is shown that any animal or article liable to seizure and found in the possession of any person was bought by such person or was consigned to him from another person for the food of man, and that at the time of purchase or consignment such animal or article was liable to be seized and condemned, the seller or consignor shall be liable to be brought to trial in the district in which such animal or article was seized, and unless he is able to prove that at the time of sale or consignment he did not know, or could not with reasonable care have known, that the animal or article was in such a condition, he shall be liable to the penalty and imprisonment above named, on conviction.

A copy of any certificate granted by a veterinary surgeon under this section shall forthwith be sent by him to the chief constable of the district in which the examination took place, and the certificate itself (that is, the original) shall be sent by the person selling the animal or carcase forthwith after the sale, and not more than seven days from date of the certificate, to the chief constable of the district in which the sale took place, and if any veterinary surgeon or person shall contravene this enactment he shall be liable to a penalty of £20.

Where a person convicted of an offence under this section has within twelve months previously been convicted of an offence under this section, the Sheriff, magistrate, or justice may, if he finds that on both these occasions the offender knowingly and wilfully committed these offences, and if he thinks fit, order that a notice of the facts be affixed, in such form and manner and for any period not exceeding twenty-one days, to any premises occupied by the offender, who shall pay the costs thereof; and any person who obstructs the affixing of such notice, or removes, defaces, or conceals the notice while affixed, shall be liable to a penalty of £5. If the occupier of a licensed slaughter-house be so convicted, his licence may be cancelled.

Any person who obstructs any medical officer of health, or sanitary inspector, or veterinary surgeon in the performance of his duty under this section shall be liable to a fine or imprisonment.

(B) **In England** like powers are conferred upon the two first-named officers—*i.e.* the Medical Officer of Health and the inspector of nuisances, but not upon a veterinary surgeon, by the **Public Health Act, 1875,** sections 116–119 inclusive. The powers embrace the inspection and examination of "any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk" exposed, or deposited for purpose of or of preparation for sale.

Section 116 gives power to inspect and examine, and if the article be found unfit for the food of man, to seize and carry away the same; section 117 empowers a justice who is satisfied of the unfitness for human food of the article seized to order its destruction; section 118 enacts penalties against obstruction to any such inspection, and section 119 empowers a justice, on a complaint made on oath by the Medical Officer of Health, inspector of nuisance, or other officer, to grant a warrant to search for unsound or diseased food.

The Public Health Acts Amendment Act, 1890, section 28, extends the foregoing sections 116 to 119, to "*apply to all articles intended for the food of man.*"

Law regarding Manner in which Articles used for the Food of Man may be Manufactured and Exposed for Sale

Acts common to England and Scotland:

The Margarine Act, 1887.

"*Butter*" is defined in section 3 as "the substance usually known as butter, made exclusively from milk or cream or both, with or without 'salt or other preservative,' and with or without the addition of colouring matter"; and "*margarine*," as "all substances, whether compounds or otherwise, prepared in imitation of butter, and whether mixed with butter or not, and no such substance shall be lawfully sold, except under the name of margarine, and under the conditions set forth in this Act."

Section 4. Every person dealing in margarine, wholesale or retail, whether manufacturer, importer, consignor or consignee, or commission agent or otherwise, who is found guilty of an offence under the Act shall be liable to penalties, the amount to be determined by the number of the offences.

Section 5. Enacts that where an employer is charged with an offence, he shall be entitled to have any other person whom he charges as the actual offender brought before the Court, and if the person so charged be proved to be the actual offender, the employer shall be exempt from penalty.

Section 6. Enacts that every person dealing in margarine shall conform to the following regulations:—

Every package, open or closed, containing margarine, shall be branded or durably marked "margarine" on top, bottom, and sides, in printed capital letters, *not less than ¾ of an inch square.* If the margarine be exposed for sale by retail, there shall be attached to each parcel a label marked "margarine" in printed capital letters not less than 1½ inches square.

Any person selling margarine, save in a package duly marked as above, shall in every case deliver the same in a paper wrapper on which is printed in capital letters the word "margarine."

Section 7. Every person in any way dealing with margarine for purposes of sale contrary to this Act, shall be liable to conviction for an offence against the Act, unless he shows to the satisfaction of the Court that he purchased the article as butter and with a written warranty to that effect, but shall be liable to pay the costs of the prosecution unless he intimates beforehand that he will rely upon the above defence.

Section 8. All margarine imported into the United Kingdom and all margarine whether imported or manufactured within the United Kingdom, shall be duly consigned as margarine, and any officer of customs or Inland Revenue, or medical officer of health, sanitary inspector, or police constable, acting under section 13 of the Sale of Food and Drugs Act, 1875, to procure samples for analysis, may take samples from any such package for analysis, if necessary.

Section 9. Every manufactory of margarine within the United Kingdom shall be registered by the owner or occupier thereof with the Local Authority from time to time as the Local Government Board may direct, with penalty in case of failure to register.

[This section is amended by section 7 of the Sale of Food and Drugs Act, 1899, as follows:—Every occupier of a manufactory of margarine or margarine-cheese, and every wholesale dealer in the same, shall keep a register showing (1) the quality, and (2) the destination of each consignment of such substances sent from such manufactory or place of business, and such register shall be open to the inspection of any officer of the Board of Agriculture; and any officer of such Board shall have power at all reasonable times to enter any such manufactory or place of business, to inspect any process of manufacture therein, and to take samples. If any occupier or dealer (*a*) fails to keep such a register, or (*b*) refuses to produce the register when called for by an officer of the Board of Agriculture, or (*c*) fails to keep such register posted up to date, or (*d*) wilfully makes any false entry therein, or (*e*) fraudulently omits to enter any particular which ought to be entered therein, he shall be liable to a penalty. The provisions of section 9 of the Margarine Act, 1887, relating to registration of manufactories, shall extend to any premises of a wholesale dealer in margarine or margarine-cheese; and such registration shall be forthwith notified by the Local Authority to the Board of Agriculture.]

Section 10. Any officer authorised to take samples under the Sale of Food and Drugs Act, 1875, *may, without going through the form of purchase provided by that Act, but otherwise acting in all respects as in that Act dealing with samples,* take for analysis samples of any butter or substances purporting to be butter, which are exposed for sale, and are not marked margarine; any such substance so exposed and not so marked shall be presumed to be exposed for sale as butter.

Section 11. Deals with destination of penalties recovered after prosecutions under the Act.

Section 12. Enacts that all proceedings under this Act, save as expressly varied by this Act, shall be the same as prescribed by sections 12 to 28 inclusive of the Sale of Food and Drugs Act, 1875, and all officers employed under that Act are hereby empowered and required to carry out the provisions of this Act.

The Margarine Act has been further amended by the **Sale of Food and Drugs Acts, 1899,** in the following provisions :—

Section 5. The provisions of the Margarine Act, 1887, shall extend to margarine-cheese, and shall apply accordingly, with the substitution of "margarine-cheese" and "cheese" for "margarine" and "butter," and provided that all margarine-cheese sold or dealt in otherwise than by retail shall either be enclosed in packages marked in accordance with the Margarine Act, 1887, as amended by this Act, or be itself conspicuously branded with the words "margarine-cheese."

Section 6. Where under this Act or the Margarine Act it is required that any package containing margarine or margarine-cheese shall be branded or marked, the brand or mark shall be on the package itself and not solely on a label, ticket, or other thing attached to the package. The letters on the paper wrapper in which margarine or margarine-cheese is sold shall be *capital block letters not less than ½ an inch long and distinctly legible, and no other printed matter shall appear on the wrapper.*

Section 8. Makes it unlawful to make, sell, expose for sale, or import any margarine the fat of which contains more than 10 per cent. of butter fat, and any person who so contravenes shall be guilty of an offence under the Margarine Act, 1887, and any defence which would be defence under section 7 of that Act shall be a defence under this section, and the provisions of section 7 shall apply accordingly.

Section 10. Enacts that in the case of any margarine or margarine cheese forwarded by a public conveyance of which a sample has been taken by an authorised officer, such officer shall send, by registered parcel or otherwise, a portion of the sample marked and sealed or fastened up, to the consignor if his name and address appear on the package from which the sample has been taken.

Section 25. Defines the expression "*margarine-cheese*" to mean any substance, whether compound or otherwise, which is prepared in imitation of cheese, and which contains fat not derived from milk: and the expression "cheese" to mean the substance usually known as cheese, containing no fat derived otherwise than from milk.

The Sale of Horseflesh, etc., Regulation Act, 1889.

Section 1. No person shall sell, offer, expose, or keep for sale any horseflesh for human food, elsewhere than in a shop, stall, or place over or upon which there shall be at all times painted, posted, or placed in *legible characters, not less than four inches in length*, and in a conspicuous position, and so as to be visible whether by night or day while such horseflesh is being offered or exposed for sale, *words indicating that horseflesh is sold there.*

Section 2. Forbids any person supplying to any purchaser any horseflesh who has asked to be supplied with some meat other than horseflesh or with some compound article which is not ordinarily made of horseflesh.

Section 3. Empowers a medical officer of health or inspector of nuisances, or other officer of a Local Authority, to inspect and examine at all reasonable times any meat which he has reason to believe to be horseflesh, exposed for sale in any unauthorised place, and if any such meat appears to him to be horseflesh, to seize and carry away or cause to be seized and carried away the same in order that it may be dealt with by a justice.

Section 4. Empowers a justice to grant warrant for search; section 5, to make an order for the disposal of seized horseflesh; and section 6, deals with penalties for contraventions of the Act.

Section 7. Defines "horseflesh" to include the flesh of asses and mules, and shall mean horseflesh, cooked or uncooked, alone or accompanied by or mixed with any other substance.

Section 8. Determines the Local Authorities in London, in England, and in Ireland, who shall administer the Act, and section 9, the Local Authorities in Scotland. **Section 9** also enacts that the procedure for the enforcement of the Act shall be in the manner provided in section 33 of the Sale of Food and Drugs Act, 1875.

MILK SUPPLY.

Dairies, Cowsheds and Milkshops Orders of 1885, 1887, and 1899.

These Orders apply to England and Wales and Scotland.

By the Contagious Diseases Animals Act, 1878, section 34, powers to make Orders in regard to dairies, cowsheds and milkshops were conferred upon the Privy Council, and by the Amending Act of like title of 1886, section 9, it was enacted that these powers should be transferred and be exercisable by the Local Government Boards; any regulations made by Local Authorities under the Order of 1885 were to be deemed to have been made by the L. G. Board and Local Authorities under the Amending Act.

The Contagious Diseases (Animals) Act, 1878, section 34, as amended by section 9 of the Act of 1886, is as follows:—The L. G. Board may make such general or special orders as they think fit, subject to the provisions of this Act, for all or any of the following purposes:—(1) registration of all persons trading as cowkeepers, dairymen, or purveyors, with the Local Authority; (2) inspection of cattle in dairies, prescribing of lighting, ventilation, cleansing, drainage, and water-supply of dairies and cowsheds occupied by persons as cowkeepers or dairymen; (3) securing cleanliness of milk-stores, milk-shops, and milk-vessels used for containing milk for sale by such persons; (4) prescribing precautions to be taken for protecting milk against infection or contamination; and (5) authorising a L. A. to make regulations for all or any of the purposes named, subject to conditions prescribed by the L. G. B.

I. Order of 1885.

Articles 1, 2, 3, 4, 5 are legal in character.

Article 6. Declares (1) it shall not be lawful for any person to carry on in the district of any L. A. the trade of cowkeeper, dairyman, or purveyor of milk, unless he is registered as such therein; (2) every L. A. shall keep a register of all such persons, and shall from time to time revise and correct the register; (3) the L. A. shall register every such person, but the fact of such registration shall not be deemed to authorise such person to occupy as a dairy or cowshed any particular building, or in any way preclude any proceedings being taken against him for non-compliance with or infringement of any provisions of this Order or any regulations made thereunder; (4) the L. A. shall from time to time give public notice by advertisement in a newspaper circulating in their district, or by handbills, or otherwise, of registration being required, and of the mode of registration ; (5) a person who carries on the trade of cowkeeper or dairyman for the purpose only of making and selling butter and cheese, or both, and not of purveying milk, need not be registered ; (6) a person who sells milk of his own cows in small quantities to workmen or neighbours for their accommodation, shall not be deemed a purveyor of milk and need not be registered.

Article 7. Deals with the construction and water-supply of new dairies and cowsheds. For details see p. 135.

Article 8. Enacts it shall not be lawful for any person following the trade of cowkeeper or dairyman to occupy as a dairy or cowshed any building, whether so occupied before the commencement of this Order or not, if and so long as the lighting and the ventilation including air-space, and the cleansing, drainage, and water-supply thereof are not such as are necessary and proper—

(*a*) For the health and good condition of the cattle therein ; and

(*b*) For the cleanliness of milk-vessels used therein for containing milk for sale ; and

(*c*) For the protection of the milk therein against infection or contamination.

Article 9. It shall not be lawful for any person following the trade of cowkeeper, or dairyman or purveyor of milk, or being the occupier of a milk-store or milk-shop—

(*a*) To allow any person suffering from a dangerous infectious disorder or having recently been in contact with a person so suffering, to handle milk-vessels or in any way to take part or assist in the conduct of the trade of cowkeeper, etc., so far as regards the production, distribution, or storage of milk ; or

(*b*) If himself so suffering, etc., to milk cows, or handle vessels, or in any way take part in the business, so far as regards the production, etc., of milk.

Article 10. Makes it unlawful for any person following the trade of cowkeeper, etc., after receipt of a notice of not less than one month from the L. A. calling attention to the provisions of this Article, to permit any w.c., earth-closet, privy, cesspool, or urinal to be within, communicate directly with, or ventilate into, any dairy or any room used as a milk-store or milk-shop.

Article 11. Makes it unlawful for any such person to permit a milk-store or milk-shop in his possession to be used as a sleeping apartment, or for any purpose incompatible with the proper preservation of the cleanliness of the milk-store or milk-shop and of the milk-vessels and milk therein, or in any manner likely to contaminate the milk therein.

Article 12. Forbids such person to keep any swine in any cowshed or other building used by him for keeping cows, or in any milk-store or other place used by him for keeping milk for sale.

Article 13. Enacts that a L. A. may from time to time make regulations for all or any of the following purposes :—(*a*) for inspection of cattle in dairies ; (*b*) for prescribing and regulating the lighting, ventilation, cleansing, drainage, and water-supply of dairies and cowsheds occupied by persons following the trade of cowkeepers or dairymen ; (*c*) for securing cleanliness of milk-stores, milk-shops, and of milk-vessels used for containing milk for sale by such persons ; (*d*) for prescribing precautions to be taken by purveyors of milk and retail sellers of milk against infection or contamination.

Article 14 was revoked, and for it was substituted Article II. of the Order of 1899, which declares that regulations made by a L. A. under the Order shall not take effect until they have been submitted to and confirmed by the L. G. Board, who may allow or disallow the same as they think proper ; nor shall any such regulations be confirmed (1) unless notice of intention to apply for confirmation of the same has been given in local newspapers, or by handbills posted throughout the district, one month at least before such application is made, and (2) unless one month at least before any such application is considered, a copy of the proposed regulations has been kept at the office of the L. A., and, in the case of districts other than burghs, at the office of the Parish Council, and has been open thereat to inspection of ratepayers of the district without fee or reward during office hours. Any person aggrieved by any proposed regulation may within such last-mentioned month forward notice of his objection to the L. G. Board, and the clerk to the L. A. shall furnish to such person on application a copy of the proposed regulations at a charge of 6d. for every hundred words contained in such copy.

Article 15. Deals with evidence of disease among cattle. By Article III. of the Order of 1899, it was altered so as to include tubercular disease of the udder. (See p. 420.)

Article 16. Declares that all orders and regulations made by a L. A. under the order of 1899 or any Order revoked thereby, and in force at the making of this Order shall, so far as the same are not varied by or are inconsistent with this Order, remain in force until altered or revoked by the L. A.

Article 17. Declares that nothing in this Order shall be deemed to interfere with the operation of The Cattle-Sheds in Burghs (Scotland) Act, 1866.

II. **Amending Order of 1887** deals solely with the transference of powers of the Privy Council to the L. G. Boards, and in Scotland with the change of authority from the Privy Council to the Board of Supervision, since superseded by the Local Government Board for Scotland.

Cattle-Sheds in Burghs (Scotland) Act, 1866

This Act enacts, section 3, that the Magistrates of royal and parliamentary burghs shall require all cattle-sheds and cow-houses and byres within their burghs to be inspected by an officer appointed by them, and, if found suitable for such purposes, to be licensed by them for the period of one year, and shall have power to make rules and regulations for the proper sanitary conditions of the same, and to fix and determine in each licence the number of cattle which may be kept therein ; and if any person shall keep any cattle within any burgh without such inspection and licence, or shall violate any rules or regulations made by the Magistrates, he shall be liable to a penalty for the offence and to a penalty for every day of continuance after conviction ; section 4 makes like enactments in the case of police burghs ; that is, burghs which have adopted " The Police and Improvement (Scotland) Act, 1862," or, previously, " The Police of Towns (Scotland) Act, 1850 " ; section 5 enacts that the Magistrates before whom any person is convicted of non-observance of any of the regulations made under this Act may, as often as they see cause, by writing require the owner or occupier of such cattle-shed, etc., to make such sanitary improvements in the same as they shall direct, within one month from the date of such written notice, and, in case of non-compliance with such notice, suspend for any period not exceeding one month the licence granted to such person under this Act ; and may, after a second conviction, in addition to the penalty, revoke such licence, and when such licence is so revoked may refuse to grant any licence whatever to such person ; section 6 enacts that every licence granted shall continue in force for a year, unless so suspended or revoked, shall require to be renewed once in every year, and shall be granted free of charge ; and section 7 enacts that before any licence for the use of any cattle-shed, cow-house, or byre can be granted, 14 days' notice of the intention to apply for the same shall be given in writing to the Magistrates or Commissioners.

Public Health (Regulations as to Food) Act, 1907

It is enacted in section 1 (1) of this Act that the power to make regulations under the English Public Health Act, 1896, shall include the power to make regulations authorising measures to be taken for the prevention of danger to public health from the importation, preparation, storage, and distribution of articles of food or drink (other than drugs or water) intended for sale for human consumption, and that, *inter alia*, the regulations may provide for the examination and taking of samples of any such articles; (2) for the purposes of regulations made under this Act, articles commonly used for the food or drink of man shall be deemed to be intended for sale for human consumption unless the contrary is proved; and (3) that in the application of this Act to Scotland, Part IV. of the P. H. (Scot.) Act, 1897, shall be substituted for the Public Health Act, 1896.

In virtue of those powers the L. G. Board for Scotland issued " **The Public Health (First Series: Unsound Food) Regulations (Scotland), 1908**," in an Order of date 25th November 1908, in which (Art. III.) the M. O. H. is empowered to examine any article of food which has been landed within the district, or while it is on board ship, or delivered overside but before landing; the master of the ship shall, when asked by the M. O. H., give him access to the ship for such examination, and shall unpack or uncover so much of the cargo as the M. O. H. may reasonably require. If, on examination, the M. O. H. is of opinion that the food is unsound, unwholesome, or unfit for human consumption, he may himself, or by an assistant, seize and carry away the same, or, by notice in writing to the importer, shipmaster, or other person in charge, require that the food shall not be removed without his permission, until the decision of a Sheriff, Magistrate, or Justice has been given. Art. IV. declares that if on a complaint of the M. O. H. that such food is unsound, etc., a Sheriff, etc., is satisfied that the food is unsound, etc., and that there is an absence of proof that the food was not intended for human consumption, he shall condemn the food and order its destruction or disposal by such means and in such manner as to prevent its use for human consumption. Art. V. declares that where the M. O. H. has reason to believe that an article of food landed in the district has not been examined by him, and when he has been refused access to make such examination, he may make complaint to a Sheriff, Magistrate, or Justice, who may thereupon issue a warrant authorising the M. O. H. to enter the premises, and to search for, seize, and carry away the article of food; that the person in custody of the premises named in the warrant shall afford all facilities as the M. O. H. may require in his search; and that the food, when found, shall be dealt with, if unsound, in terms of Art. IV. Where unsound food is destroyed, Art. VI. declares that the L. A. shall keep a record of the same, and shall retain the record for not less than twelve months. Art. VII. empowers the M. O. H. to take a sample from a consignment of articles of food for any purpose of these Regulations, and shall dispose of the sample in such manner as the L. A. direct. Where the M. O. H., in respect of any such sample, is of opinion that special procedure is necessary for its examination, or where, at the request of the importer, the M. O. H. has recourse to special procedure for such examination, the importer or other person in custody of such sample shall afford during 48 hours as the M. O. H. by notice in writing appoints, or longer if the importer consents, all such facilities as the M. O. H. may reasonably require for completion of his examination of the articles of food. The L. A. may appoint a legally qualified medical practitioner to act in the execution of these Regulations, either in the place of, or as an assistant to, the M. O. H. and (2) a person to act under the direction of the M. O. H. in discharging any such duties of the M. O. H. under these Regulations as the L. A. assign to the person appointed (Art. X.). Two or more Local Authorities shall act together for the foregoing purposes in every case in which the L. G. Board require any such joint action.

Under the same Order, and on the same date as the foregoing, the Board also issued " **The Public Health (Foreign Meat) Regulations (Scotland), 1908**."

These Regulations are designed to deal with (*a*) *foreign boneless meat* imported in the form of scraps, trimmings, or other pieces not sufficiently identifiable with definite parts of a carcase, and not before importation made ready for human consumption in the form of a sausage, or other prepared or manufactured article of food; (*b*) *with imported tripe, tongues, or kidneys to which certain chemical preservatives have been applied*; and (*c*) *with severed parts of a pig* not prepared before importation as bacon or ham, and not contained in a package with an "official certificate" impressed on it, or affixed or attached to it. Such "official certificate" means a certificate, label, mark, stamp, or other voucher which, by a notice published in *The Edinburgh Gazette* at any time during the twelve months beginning 1st October 1908, is declared to be admissible as evidence that the cattle or pig from which the meat is derived has been certified by a competent authority in the place of origin to be free from disease at the time of slaughter, and that the meat has been certified by a like authority to have been dressed or prepared and packed with due care to prevent danger arising to public health from the meat as an article of food. Such meats are denominated "**Foreign Meat of Class I.**"; and unless the importer of such furnishes proof that it is not intended for sale for human consumption, the meat is required to be destroyed. Foreign meat which, being in the form of the entire carcase of a pig, has not, before importation, been salted or otherwise prepared as bacon or ham, and is without the head in its natural state of attachment to the carcase, and is without the lymphatic glands about the throat, and any other part of the carcase in their natural position, is called "**Foreign Meat of Class II.**"; and foreign meat in the form of severed parts of the carcase of a pig, or of other edible parts of a pig, which has not, before importation, been salted or otherwise prepared as ham or bacon, which is not and does not comprise any "foreign meat of Class I.," and which is contained in a package with an official certificate impressed thereon or affixed or attached thereto, is called "**Foreign Meat of Class III.**" Any foreign meat other than foreign meat in any of the forementioned classes is denominated "**Foreign Meat Unclassed.**"

According to Article III.—(1) the officer of customs on a ship arriving within the district, shall ascertain whether the cargo comprises any foreign meat; (2) where he finds, or has reason to believe, that such meat of Class I. or of Class II. is comprised in the cargo, he shall, by a notice in writing to the shipmaster or to the importer, require that such meat shall not be removed from the ship or any other place specified in the notice, until it has been examined by the Medical Officer of Health, and he shall, at the same time, inform the M. O. H. to the effect of the notice; (3) where the Customs Officer finds that the cargo comprises foreign meat of Class III. or Foreign Meat Unclassed, he may allow the meat to be removed, unless he is of opinion that the meat requires to be examined by the M. O. H., in which latter case he shall proceed by a written notice and otherwise as in (2); (4) where any notice has been given in relation to any foreign meat in pursuance of subdivision (2) or (3) of this Article, no person shall remove the meat from the ship or other place specified in the notice without the express permission of the Customs Officer, before its examination by the M. O. H.; (5) when informed by the Customs Officer as to the effect of the notice given in respect of the foregoing subdivisions, the M. O. H. shall proceed forthwith to examine the foreign meat to which the notice relates. If, thereafter, the M. O. H. is of opinion that the meat may be removed to a place of destination in Scotland for any purpose other than exportation, he shall give a certificate in writing to that effect, but if not of that opinion, he shall by notice in writing forbid the removal of the meat for any purpose other than exportation. (6) Every certificate and every notice given by the M. O. H. shall describe the foreign meat to which it relates, so that the consignment may be identified; and every certificate shall be in duplicate, and every notice in triplicate. One copy of the certificate shall be given by him to the Customs Officer and one copy to the importer. One copy of any notice shall be given by him to each of these respectively, and one copy to the Local Authority. He shall not give a certificate and shall give a notice as regards Foreign Meat of Class I. and Foreign Meat of

Class II., and he shall not give a certificate and shall give a notice as regards Foreign Meat of Class III. or Foreign Meat Unclassed if, in his opinion, despite the official certificate, the meat is diseased, unsound, unwholesome, or unfit for human consumption.

Article VI.—The Local Authority, within 12 hours after receipt of a copy of a notice by the M. O. H., in pursuance of subdivision (5) of Article III., or of Article IV. (1) [where the meat having been removed by permission of the Customs Officer is still within the district, and where the M. O. H. after examining it is of opinion as in Article III. (5)], shall give notice in writing to the importer which shall state, *inter alia*, that, unless within 12 hours after receipt thereof the importer gives to the L. A. a written undertaking that he will export the meat at his own expense, or, in proceedings before a Sheriff, etc., he will prove (1) that the meat is not diseased, etc., or (2) that it is not intended for sale for human consumption, the L. A. will cause the meat to be destroyed under the supervision of the M. O. H. Where no written undertaking by the importer is forthcoming within the time specified in the notice, the Local Authority shall forthwith cause the meat to be destroyed ; but if, on the other hand (Art. VII. (2)), such an undertaking has been given, and notwithstanding such undertaking, the meat is not exported by the importer, the L. A. shall forthwith proceed to destroy the meat. In these Regulations in respect of foreign meat as in those of unsound food, provision is made for the appointment by the L. A. of a legally qualified medical practitioner as substituted for or assistant to the M. O. H., and of a person to act under his direction in the execution of the Regulations (Art. XV.). Two or more Local Authorities shall combine for joint action respecting these Regulations when called upon by the L. G. Board so to combine.

In both Regulations provision is made for the settlement of differences arising out of the same by arbitration of the L. G. Board. The chemical preservatives referred to which are forbidden are (*a*) formalin, or a solution or preparation of formic aldehyde ; (*b*) compounds of fluorine or boron ; (*c*) salicylic acid ; (*d*) formic acid ; (*e*) sulphurous acid ; (*f*) benzoic acid ; or (*g*) any compound of any such acids.

Law in regard to Defective or Adulterated Food and Drugs

I. The Sale of Food and Drugs Act, 1875.
II. The Sale of Food and Drugs Amendment Act, 1879.
III. The Sale of Food and Drugs Act, 1899.

These three Acts are to be read together. They apply to Great Britain and Ireland.

The following expressions are defined in these Acts as follow :—

"*Food*" *shall include every article used for food or drink by man, other than drugs or water, and any article which ordinarily enters into or is used in the composition or preparation of human food, and shall also include flavouring matters and condiments.* (Act, 1899, section 26.)

"*Drug*" shall include medicine for internal or external use. (Act, 1875, section 2.)

"*Exhausted Tea*" shall mean and include any tea which has been deprived of its proper quality, strength, or virtue by steeping, infusion, decoction, or other means.

"*Local Authority*" means any Local Authority authorised to appoint an analyst for the purposes of these Acts, and the expression *Public Analyst* means an analyst so appointed. (Act, 1899, section 3, sub-sections (1) and (5).)

By a General Order of the Scottish Local Government Board of date April 17, 1900, in virtue of their powers under the latter sub-section of section 3 of the Act of 1899, it is laid down that any person appointed to the office of Public Analyst on and after Jan. 1, 1900, shall furnish such proof as the Board may deem sufficient of his competent skill in and knowledge of (*a*) analytical chemistry, (*b*) therapeutics, and (*c*) microscopy; and such proof shall comprise documentary evidence that such person holds the requisite certificate, diploma, licence, or document, conferring the qualification or attesting the possession of such necessary skill or knowledge, and such other evidence as may be required in any particular case.

I. Provisions of Act of 1875—the principal Act.

Offences. Section 3. No person shall mix, colour, stain, or powder, or permit or order any other person so to do, *any article of food* with any ingredients or material, so as to render the article injurious to health with intent that such article may be sold in that state, and no person shall sell any such article so mixed, coloured, etc., under a penalty in each case not exceeding £50 for the first offence. Every conviction, after a conviction for a first offence, shall be a misdemeanour [crime or offence (Scotland)] for which the person on conviction shall be imprisoned for a period of not less than six months with hard labour.

This section is amended and extended by sub-section 2, section 17, of the Act of 1899, to the effect that where, under these Acts, a person is guilty of an offence liable to a fine larger than £50, and where, in the opinion of the court, the offence was committed by the personal default, act, or culpable negligence of the person accused, the Court may sentence the accused to imprisonment for not more than three months with or without hard labour.

Section 4. No person shall, except for the purpose of compounding, mix, colour, stain, or powder, or order or permit any other person so to do, *any drug* with any ingredient or material to affect injuriously *the quality or potency of such drug*; and so on, as in preceding section.

Section 5. Provided that no conviction shall follow in either of the forementioned sections, if the person shows to the satisfaction of the justice or Court that he *did not know of the article of food or drug sold by him being so mixed, coloured, etc., and that he could not with reasonable diligence have obtained that knowledge.*

Section 6. No person shall sell *to the prejudice of the purchaser* any article of food or any drug which is not of the *nature, substance, and quality of the article demanded* by the purchaser, under penalty not exceeding £20, provided that an offence shall not be deemed to be committed in the following cases:—

(1) Where any matter or ingredient not injurious to health has been added because the same is required for its preparation or production as an article of commerce in a state fit for carriage or consumption, and not fraudulently to increase its bulk or conceal its inferior quality; (2) where the drug or food is a proprietary medicine, or a patent, and is supplied according to specification; (3) where the food or drug is compounded as in this Act mentioned; (4) where the food or drug is unavoidably mixed with extraneous matter in the process of collection or preparation.

This is amended by the Amendment Act of 1879, section 2, to the effect that where in any prosecution under section 6 of the Act of 1875 any sale of any substance which is not of the nature, substance, and quality of the article demanded has been made, *it shall be no defence to allege that the purchaser, having bought only for analysis, was not prejudiced by such sale; nor shall it be a good defence to prove that the* article of food or drug bought, though defective in nature or substance, or quality, was not defective in all three respects.

Section 7. No person shall sell any compound food or compounded drug, which is not composed of ingredients as demanded by the purchaser, under penalty of not more than £20.

Section 8. No person shall be guilty of an offence who sells a mixed food or drug, if the ingredient added be not injurious to health and is not intended fraudulently to increase its bulk, weight, or measure or to conceal inferior quality, provided that at the time of delivery he shall supply a notice, by a label distinctly and legibly written or printed on or with the article or drug, to the effect that the same is mixed. Section 12 of the Act of 1899 declares, that the label referred to in this section shall not be deemed to be distinctly and legibly written or printed, unless it is so written or printed that the notice of the mixture given by the label is not obscured by other matter on the label. But nothing shall affect the use of any trade-mark or of any label which has been in use continuously for at least seven years before the commencement of this Act.

Section 9. It shall be an offence for a person, with intent to sell any article in its altered state, to abstract from an article of food or part of it, so as to affect injuriously its quality, substance, or nature, or sell such article in its altered state without making disclosure of such alteration.

Sections 10 and 11. Deal respectively with the appointment of a Public Analyst by Local Authorities singly or in combination.

Procedure on Suspicion of Adulteration.

Section 12. Any purchaser of any article of food or of a drug in any place where there is an analyst appointed, on payment to such analyst of a sum not more than 10s. 6d. or if there be no such analyst, to the analyst of another place, of any sum as may be agreed upon between such person and the analyst, shall be entitled to have the article analysed by such analyst, and to receive from him a certificate of result of said analysis; and (section 13) any officer appointed and paid by the Local Authority may procure any sample of food or drugs for analysis.

Section 14. The person purchasing any article for analysis *shall*, after purchase has been completed, *forthwith notify the seller or his agent of his intention to have the article analysed, and shall* [offer to] *divide the article into three parts to be then and there separated, and each part to be marked and sealed or fastened up in such manner as its nature will permit, and shall* [proceed accordingly and shall], *if required to do so, deliver one of the parts to the seller or his agent.* He shall *retain* one of the said parts for future comparison, and submit the third part, if he deems it right to have the article analysed, to the analyst.

[*Note.* The words enclosed in square brackets in this section were repealed by section 13 of the Act of 1899.

Where the article is bought by an officer of the Local Government Board or of the Board of Agriculture for analysis, it must be divided into four parts, in terms of section 2 of Act of 1899.

If the analyst resides beyond two miles of the residence of the person requiring analysis of any article so bought, such person may forward through the post office such article as a registered [letter] parcel.

The word "letter" was repealed by the Act of 1899, section 15, and "parcel" substituted therefor.]

Refusal to sell officer samples for analysis.

Section 17. If any officer, etc., shall apply to purchase any article of food or drug exposed for sale, or on sale by retail, on any premises or in any shop or stores, and shall tender the price for the quantity he shall require for the purpose of analysis, and the person exposing the same for sale shall refuse to sell the same, such person shall be liable to a penalty of not more than £10.

[This section is amended and extended by section 18 of the Act of 1899, to the effect that where the article is exposed for sale, in an unopened tin or packet duly labelled, the exposer shall not be compelled to sell it except in that form.]

Section 18. Deals with the schedule form of analyst's certificate which in the prescribed form is a condition precedent to a prosecution and to a conviction.

Where a person has received from the analyst a certificate regarding the article which he bought and submitted to the analyst for analysis to the effect that an offence has been committed under this Act, he may take proceedings against the seller before a Sheriff in whose jurisdiction the article in question was sold (section 20). Any prosecution shall not be instituted after the expiration of 28 days from time of purchase, and the summons shall state particulars of offence alleged, the name of the prosecutor, and with it shall be sent a copy of the certificate of the analyst. (Section 19 of Act of 1899.)

The production of the analyst's certificate shall be *prima facie* evidence of the facts therein stated. and shall be sufficient evidence, unless the defender requires that the analyst should be called as a witness, and the parts of the article bought which have been retained by the purchaser be produced. Defender and his wife may be examined on defender's behalf. (Section 21.) (Also Section 22, Act of 1899.)

The Sheriff in Scotland or the justices in England may, on request of either party, cause the article in question to be sent to the Commissioners of Inland Revenue, who shall direct their chemical officers at Somerset House to make the analysis, and give a certificate to such Sheriff or justices, the expense of the same to be paid by the prosecutor or defender as the Sheriff or justices may by order direct. (Section 22.)

The Sheriff or Court may, without any such request, cause the article to be sent for analysis to the Inland Revenue Commissioners. (Section 21, Act of 1899.)

In any prosecution under this Act the defender has to prove, where he raises the question in defence, that he is protected by any provision contained in the Act. (Section 24.)

When Defenders should be Discharged.—The defender is to be discharged if he prove that he had bought the article as the same in nature, substance, and quality as that demanded of him, and with a *written warranty to that effect*, that he had no reason to believe at the time of the sale that the article was otherwise than, and that he sold it in the same state as when he purchased it. If he give due notice to the prosecutor that he is to rely upon this as a defence he shall not be liable to costs incurred by prosecutor. (Section 25.) Any person who forges a warranty, or falsely issues or uses any writing purporting to be a warranty, or wilfully gives or uses a label which falsely describes any article sold by him, shall be liable to penalties. (Section 27.)

Special Provisions as to Tea.—On and after 1st Jan. 1876, all tea imported as merchandise into the United Kingdom shall be subject to examination by persons appointed by the Customs Commissioners for inspection and analysis, and if analysis shows that any such tea is mixed with other substances or is *exhausted* tea, the same shall not be delivered unless with the sanction of the said Commissioners, either for home consumption or for ships' stores or for exportation. If found unfit for human food, it shall be forfeited and destroyed, or otherwise disposed of as the Commissioners may determine. (Section 30.)

II. The Amendment Act of 1879, has for its main provisions the following :—

Section 2 removes the defect of the Act of 1875 with respect to prejudice to the purchaser where an article was bought for analysis. (*Vide* section 6 of Act of 1875, p. 539.)

Provisions with Regard to Delivery and Sale of Milk.—Any medical officer of health, sanitary inspector, inspector of weights and measures, or any inspector of a market, or police constable appointed by, under the direction of, or charged with the execution of this Act, by the Local Authority, may procure *at the place of delivery* any sample of any milk *in course of delivery* to any purchaser or consignee *in pursuance of any contract* for the sale of such milk, and if he suspects that such milk is being sold contrary to the provisions of the principal Act (1875), shall submit the same to be analysed, and on conviction penalties shall be enforced *as if such officer had purchased the same from the seller or consignor* under section 13 of the Act of 1875 (section 3). Any person obstructing any such officer in the taking of such samples, or refusing him to take the same, shall be liable to a penalty (section 4). Section 14 of the Act of 1899 enacts that the provisions of the foregoing sections 3 and 4 *shall apply to every other article of food* ; provided that no samples shall be taken under s. 14 of the Act of 1899, except upon the request or with the consent of the purchaser or consignee. Any street or open place of public resort shall be held to come within the meaning of section 17 of the Act of 1875 (*vide ante*). (Section 5.)

Provisions with Regard to Alcoholic Liquors.—In determining whether an offence has been committed under section 6 of the principal Act (*vide ante*) by selling spirits not adulterated otherwise than by admixture of water, it shall be a good defence to prove that such admixture has not reduced the spirit more than twenty-five degrees under proof for brandy, whisky, or rum, or thirty-five degrees under proof for gin. (Section 6.)

Note.—Proof Spirit, as defined by the 58 Geo. III., is "such as shall, at the temperature of 10° C., weigh exactly twelve-thirteenth parts of an equal measure of distilled water." In accordance with the standards set in the preceding section, brandy, whisky, and rum should not contain less than 36 per cent. of absolute alcohol by weight, and 64 per cent. of water; and gin, 30·78 per cent. of absolute alcohol by weight, and 69·22 per cent. of water.

The remaining sections 8 and 10 have been repealed by the Act of 1899, and sections 7 and 9 deal with legal points.

III. Sale of Food and Drugs Act, 1899.

This Act was passed to amend and extend the provisions of the former Food and Drugs Acts, 1875 and 1897, and the Margarine Act, 1887. We have already incorporated in their proper place the provisions of this Act which amend the previous Acts. It is sufficient now to indicate the new ground covered by this Act.

1. **Precautions regarding Insufficient Marking of Imported Foods.**—If there be imported into the United Kingdom any of the following articles—

(*a*) Margarine or margarine-cheese, except in packages conspicuously marked *Margarine* or *Margarine-cheese*, as the case may require; or

(*b*) Adulterated or impoverished butter (other than margarine) or adulterated or impoverished milk or cream, except in packages or cans conspicuously marked with a name or description indicating that the butter, milk, or cream has been so treated; or

(*c*) Condensed, separated, or skimmed milk except in tins or other receptacles which bear a label whereon the words *machine-skimmed milk* or *skimmed milk* as the case may require, are *printed in large and legible type*; or

(*d*) Any adulterated or impoverished article of food to which his Majesty may by order in Council direct that this section shall be applied, unless the same be imported in packages or receptacles conspicuously marked with a name or description indicating that the article has been so treated;

the importer shall be liable on summary conviction to monetary penalties.

The word "importer" shall mean the person in possession of or in anywise entitled to the custody or control of the article. Prosecutions under this section shall be undertaken by the Commissioners of Customs, who shall, after consultation with the Board of Agriculture, (1) take samples of consignments, (2) divide such sample into *not less than three parts*, send one to the importer, one to the chief chemist of the Government Laboratories, and retain one part. The certificate of the principal chemist, in any action under this section, shall be sufficient evidence of the facts therein stated unless the defender requires that the analyst shall be called as a witness. If the Commissioners are of opinion that an offence has been committed, they shall communicate to the Board of Agriculture the name of the importer and such other facts as they possess or may obtain as to the destination of the consignment.

Any article shall be deemed to be adulterated or impoverished if it has been mixed with any other substance, or if any part of it has been abstracted, so as in either case to affect injuriously its quality, substance, or nature; but no food shall be deemed to be adulterated by the addition only of any preservative or colouring matter of such a nature and in such quantity as not to render the article injurious to health. (Section 1.)

The Local Government Board may, relative to any matter affecting the general interest of consumers, and the Board of Agriculture, relative to any matter affecting the general interests of agriculture in the United Kingdom, direct an officer to procure for analysis samples of any article of food, who shall have all the powers of procuring samples under the Sale of Food and Drugs Acts, except that such officer shall *divide any sample into four parts*, and shall deal with three of such parts in accordance with section 14 of the Act of 1875 (*vide ante*, p. 531), as amended by this Act, and shall send the fourth part to the Board, and the Board shall communicate the result of analysis of any such sample to the Local Authority, who shall take such proceedings as if they themselves had caused such analysis to be made. (Section 2.)

It shall be the duty of every Local Authority entrusted with the execution of the laws relating to the Sale of Food and Drugs Acts *to appoint a public analyst*, and, from time to time, to put in force the powers with which they are invested. Should the Local Authority fail so to put their powers in force, the Local Government Board or the Board of Agriculture may, after communication with such Local Authority, empower an officer of the Board to execute and enforce the provisions of the law, and any expenses incurred by the Board in this way shall be paid by the defaulting Local Authority.

Any public analyst appointed under these Acts shall furnish such proof of competency as may be required by regulations framed by the Local Government Board. (Section 3.)

The Board of Agriculture may make regulations for determining what deficiency in any of the normal constituents of genuine milk, cream, butter, or cheese, or what addition of extraneous matter or proportion of water in any sample of milk (including condensed milk, cream, butter, or cheese) shall for these Acts raise a presumption, until the contrary is proved, that the same is not genuine or is injurious to health, and an analyst shall have regard to any such regulations in certifying the result of any analysis under those Acts. Any regulations so made shall be notified in the *London* and *Edinburgh Gazettes*, and in any other manner the Board may decide. (Section 4.)

In virtue of this section the Board of Agriculture, in the **Sale of Milk Regulations, 1901,** have laid down that—

(*a*) *Milk* containing *less than* 3 *per cent. of milk-fat or less than* 8·5 *per cent. of milk-solids not fat*, and *skimmed or separated milk* (other than condensed milk) containing *less than* 9 *per cent. of total milk-solids*, is to be presumed not to be genuine :—

And by the **Sale of Butter Regulations, 1902,** that—

(*b*) *Butter* containing more than 16 *per cent. of water* is to be presumed not to be genuine.

As has already been pointed out, the provisions of the Margarine Act, 1887, extend to margarine-cheese, and packages containing any such substance shall be conspicuously branded with the words "margarine-cheese," on the package itself and not on a label, ticket, or other thing attached thereto, the letters to be capital block letters not less than half-an-inch long, and to be distinctly legible ; and no other printed matter shall appear on the wrapper. (Section 6.)

The registration of manufactories provided for in section 9 of the Margarine Act, 1887, is extended to registration of premises of wholesale dealers in margarine and margarine-cheese, and it is obligatory for every occupier of such place to keep a register showing the quantity and destination of each consignment sent out (*vide ante*, p. 531). (Section 7.)

For the provisions of sections 8, 10, and 25 of the Acts 1887–89, see pp. 531–2.

It is forbidden under a penalty for any person, or his servant, in any highway or place of public resort to sell milk or cream from a vehicle or from a can or other receptacle unless his name and address be conspicuously inscribed on the vehicle or receptacle. (Section 9.)

Where a sample of milk is taken in course of delivery, or of margarine or margarine-cheese from a public conveyance, the person taking the sample shall forward by registered parcel or otherwise a portion of the sample marked and sealed or fastened up to the consignor, if his name appears on the can or package from which the sample was taken. (Section 10.)

Every tin or other receptacle containing condensed, separated, or skimmed milk must bear a label clearly visible to the purchaser on which the words "*machine-skimmed milk*," or "*skimmed milk*," as the case may require, are printed in *large and legible type*, and any person contravening these provisions shall be guilty of an offence, and be liable to a penalty of £10. (Section 11.)

A time-limit has been placed for proceeding in offences under these Acts in section 19 of this Act, which enacts that where any article has been purchased from any person for test-purposes, any prosecution, notwithstanding the provisions of section 20 of the Act of 1875, shall not be instituted after the expiration of twenty-eight days from time of purchase, and in the summons to be served on any defender there shall be stated (1) particulars of the offence or offences alleged, (2) the name of the prosecutor, and (3) there shall accompany the summons a copy of the analyst's certificate. Such summons shall not be returnable in less than fourteen days from day of service. (Section 19.)

A warranty or invoice shall not be available as a defence in proceedings under these Acts unless the defender has, within seven days after service of summons, sent to the purchaser a copy of such warranty or invoice with a written notice stating that he intends to rely on the same, and specifying the name and address of the person from whom he received it, and has also sent a like notice of his intention to such person. The person to whom such warranty or invoice is alleged to have been given shall be entitled to appear at the hearing and to give evidence, and the Court may adjourn the hearing to enable him to do so. Any warranty or invoice given by a person resident out of the United Kingdom shall not be available as a defence, unless the defender proves that he had taken reasonable steps to ascertain, and did in fact believe in, the accuracy of the statement contained in the warranty or invoice. Where a defender is the servant of the person who purchased the article under a warranty or invoice, he shall, subject to the provisions of this section, be entitled to rely on section 25 of the Act of 1875, and section 7 of the Margarine Act, 1887, in the same way as his employer or master would have been entitled to do if he had been the defender, provided further that the servant shall prove that he had no reason to believe that the article was otherwise than that demanded by the prosecutor. Every person who gives a false warranty in writing shall be liable to penalties on conviction.

CHAPTER XVIII

DISEASES OF OCCUPATIONS

Effects of Occupation on Health.—Of the many factors the sum of which determines the condition of health and longevity of man, perhaps none is so potent as that of his daily occupation. This is as true of man as an individual as of man in the mass. The evil effects of occupation arise very largely from the grouping of workers under entirely artificial conditions in factories, yards, and workshops. Coupled with artificial environment are the high pressure and competition of the labour market, which act as a contributory strain on workmen, especially upon those who are engaged in contract work or " piece " work, in which the wages are determined not by the time occupied in the work, but by the products which the workman can finish in a given time.

Centralisation of population in towns and cities, due to the attraction of higher wages and outlets for employment for families and centralisation of labour, have mutually interacted upon each other to assist in producing results inimical to the health of the employed. These effects have been appreciated by the Legislature in the Factories and Workshops, the Dangerous Trades, and other Acts in which the young and the female sex are so far protected against protracted hours of labour, and against accidents by machinery, and in which also the health of employees is conserved by compulsory sanitary conditions of workshops and factories. This is especially true of productive industries in which the commodity is made out of the raw material. Practically no change is apparent in primitive occupations, as farming, fishing, etc., except in the former of the more extended use of labour-saving machinery, since these callings must of necessity be followed in the open air; and although in these the conditions of employment generally are more conducive to health, they have at the same time attendant hardships and disabilities which are productive of disease.

It has been computed that there are about 12,000 different occupations. This large number is doubtless due in large measure to the great subdivision of labour which has become the characteristic feature of employment during the past half-century.

All occupations may, however, be divided into three great classes, if we adopt as the means of classification the bodily powers which are chiefly involved therein—viz. (1) those in which the nervous system is most employed; (2) those in which the muscular system; and (3) those in which both in varying grades of combination are called into play. To the first class belong brain-workers generally, as authors, composers, teachers, and professional men; to the second, the " hewers of wood and drawers of water," as labourers, navvies, quay-porters, and others of like classes; and to the third, all classes of workmen who unite skill with handicraft in their occupation, and in varying degree. It would probably be correct to say that the largest proportion of the army of the employed belongs to this last class.

But another subdivision may be adopted—viz. with relation to the harmful effects which are produced by, or are incidental to, occupations. Ogle gives an excellent working classification on this basis. He divides occupations as follows :—

I. Where the workman adopts a cramped or constrained attitude during work, which prevents the healthy action of lungs and heart.

II. Where he is exposed to the action of poisonous or irritating substances used in the trade.

III. Where he is called upon to work excessively and irregularly, either mentally or physically.

IV. Where he is compelled to work in confined places in which the air is either initially foul or is likely to become so.

V. Where from the nature of the occupation he is liable to contract harmful habits.

VI. Where he is especially subject to risks to life from accident.

VII. Where he works in atmospheres which contain floating particulate matter. To these may be added another—viz.

VIII. Where he is required to work in abnormal atmospheric pressures.

As examples of the first may be cited the occupations of coal and ore-mining, clerk, seamstress, hand-loom weaver, lace-maker (on cushions), glover, shoemaker (on the last), and of bench or machine workers in a sitting or other cramped attitude generally. In all of these, more or less pressure is exercised on the chest, often most marked in the occupation of shoemaking by hand, and in which markedly permanent indentation of the sternum is produced, due to the direct pressure of the last.[1]

Of the second class are workers in arsenic, mercury, zinc and copper, lead, " chrome," phosphorus, chemical workers exposed to fumes of chlorine and sulphur gases, rubber workers to the vapours of carbon bisulphide, and other workers whose atmospheres are composed largely of vapours of tar, pitch, or resin, and others. Workers in cement factories are liable, like workers in chrome, to perforation of the cartilaginous nasal septum.[2]

Of the third class, dock labourers, porters, stevedores navvies, engineers, and athletes generally may be taken as representatives. It has been clearly demonstrated that greater harm results from severe and inconsecutive than from steady, continuous, though severe work. Where the muscular strain is confined solely to certain groups of muscles, as in shorthand writers, pressmen and journalists, musicians, telegraphists, and others, special ill effects, as writer's cramp, are apt to follow. From the mental side, ill effects are likely to arise where in pressmen and journalists " copy " has to be produced against time, or under exciting conditions.

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[1] Lane, " Anatomy and Physiology of the Shoemaker " (*Jour. of Anat. and Phys.*, July, 1888, vol. xxii., p. 593).

[2] Foulerton, *Lancet*, vol. ii., 1889, p. 314.

Tailors, hatters, slop-workers, seamstresses, bookbinders, printers, laundresses, and shopkeepers as grocers and drapers may be considered as typical of the fourth class, inasmuch as they work usually in confined and often foul air spaces.

Of the fifth class, in which vicious habits are liable to be contracted from materials used or products manufactured in the occupation, the callings of innkeeper, brewer and distiller, barman and barmaid, and of liquor dealers generally, carry with them the temptation to contract the alcoholic habit; that of cigar, cigarette, and tobacco manufacturer, the abuse of tobacco; and that of druggist, the use of opium, cocaine, ether, or other drugs, which when the habit is contracted becomes prejudicial to health.

To the sixth class more or less belong all occupations. But certain of them are necessarily attended by greater danger from accident than others, such as mining or quarrying from the use of explosives, the effects of explosion of gases and of falls of material in railway working, ship-building, house-construction, in connection with machinery generally, and in the manufacture of fireworks and the higher explosives.

The seventh class embraces a large number of occupations, and the factor common to them all which is provocative of harm is particulate matter in suspension in the working atmosphere, and which when inhaled into the respiratory passages produces lung-diseases, or when deposited upon the skin causes diseases of the skin. The effects which are produced depend upon the nature of the particulate matter; in respect whether it is organic or inorganic, living or dead, and as to whether its action is purely mechanical or is pathogenic. Where the action is purely mechanical, the character of the air-particles determines in great measure the intensity of the resulting harm both as to time and amount. The dust particles found in this class of occupations may be divided into those that are: (*a*) sharp and angular, (*b*) blunt and smooth, and (*c*) filamentous. In the following trades sharp particles are present—viz. steel-grinder (dry process), stone-cutter, sand- or glass-paper maker, potter, button-maker, file-maker (by hand), ore miner, quarrier, and gannister-worker; in the following, blunt and smooth particles—viz. wood or ivory turner, sawyer, collier, miller, baker, foundry-worker, chimney-sweep, and many others; and filamentous, in those of hemp-dressing, flax-working, hair- and wool-sorting, warehouseman, draper, cotton-spinner, wool-carder, and others. It may be held as expressive of a general principle, that the sharper the particles present in the atmosphere and inhaled by the workman, the more rapid the progress and the more severe the character of the lung-disease induced. In steel-grinding by the dry process the mortality of employees is exceedingly high, and the rapidity of the disease finds expression in the popular name by which the results are designated—viz. grinders' rot. Of non-metallic particulate bodies, probably the next most disastrous in its effects is that from the working of gannister stone, which is a very compact, highly silicious rock found in various parts of England, and which is used for making bricks which withstand very high temperatures. The hardness of the rock is such that it must be mainly removed by dynamite. All those employed in the industry, and especially the grinders, are subject to lung-disease, from which the mortality is high because of the lethal action of its sharp particles. For each 1000 men employed, the death-rate of miners is at the rate of 42·3; of grinders, 179·8; and of brick-makers, 22·2. These figures alone illustrate by comparison that a dust-laden atmosphere is the most dangerous even in employment of the same material for different purposes. The reader will obtain valuable information on this subject under the following reference.[1] The evil results of substances deposited upon the skin are occasionally seen in persons engaged in the soot traffic as chimney-sweep's cancer, in paraffin workers as skin diseases, and they are commonly found in chrome-workers as ulcerative and perforative disorders of the nasal septum, and as "chrome holes" in the form of deep ulcers of hands and arms or other part of body. It is necessary, however, to differentiate between the mechanical action of such particles, and the pathogenic action which may arise from some of them. The latter influence may very well be illustrated in the occupations of hair-, wool-, and hide-sorting, and others with relation to anthrax, and rag-sorting and paper-making with relation to smallpox. While, according to Bollinger,[2] disease originating from wool treated at the tapestry-works of Montpellier was known as far back as 1769, the credit of calling attention in this country to the serious risks of wool-sorting must be accorded to Dr Bell of Bradford, who with considerable acumen associated outbreaks of disease with certain classes of foreign wool, notably those from Russian Tartary. The Report of the Medical Officer of the Local Government Board for 1880 gives an excellent review of the whole subject, and the Report of the Chief Inspector of Factories for the same year an account of the prophylactic measures proposed to be established against the disease for the protection of workmen. These measures are, generally, that all suspicious or filthy bales of wool or hair should be steeped and thoroughly soaked in cold water, should thereafter be placed in hot soapy water and be washed, should then be passed through rollers to express the excess of water, and that they should then be sorted. Such procedure prevents the formation and spread of dust in which the spores of *B. anthracis* might be present. Further, the working-places are to be well ventilated, the floors swept daily, the walls and ceiling once in three months, and once a year the walls are to be lime-washed with lime containing carbolic acid. Provisions are to be made whereby the sorters may wash before meals, and it is enjoined that no workman should take into or eat in any sorting-room any food. In the outbreak which occurred in a hair-factory near Glasgow, and of which an account was written by Dr Russell, then Medical Officer of Health for the city, in the Report of the Medical Officer of the Local Government Board (England) for 1878–1879 (Eighth Report), several deaths resulted. *Vide* also (Scott), *B. M. J.*, vol. ii., 1900, p. 136. In hair-manufactories to prevent the diffusion of dust, short hair is treated in an enclosed machine, which is connected with a ventilating shaft by which particulate matter is carried away from the working-places. Rag-sorting and paper-making are attended also with risk from floating micro-organisms given off into the atmosphere from filthy fabrics. Outbreaks of smallpox have been caused on several occasions in this way; one in a paper-work in the neighbourhood of Edinburgh, another in the neighbourhood of Glasgow, and a third in central Lanarkshire in 1889. Other outbreaks from different organisms have also been recorded from these occupations. Such an outbreak occurred at Riga in a paper-manufactory,[1] from which fatal results arose in some of those attacked. In the blood and tissues of those who died were found micro-organisms, both bacilli and cocci, the former corresponding to Koch's bacillus of malignant œdema.

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[1] *Journ. San. Inst.*, vol. xxi., Part i., p. 66.

[2] Ziemssen's *Encyc. of Med.*

To the eighth class belong a very limited number of occupations, as bridge-pier building (in caissons), diving, workers generally under abnormally high atmospheric pressure, and ballooning and mountain-climbing in high altitudes from atmospheric rarefaction—if such can be classified under the heading of occupation. Where the occupation is carried on under increased atmospheric pressure, arrangements must be made at the entrance to the working parts whereby the air-pressure may be gradually raised to the pressure of the working parts before the workmen are allowed to enter, and may again be gradually reduced before the workmen are permitted to return to the normal atmospheric pressure. The mode by which this is attained is a metal, air-tight chamber, or air-lock as it is called, provided with suitable valves whereby the pressure is raised or lowered. The pressure in the working parts may vary from one half to three or four atmospheres of pressure above normal, the amount of pressure used in any of the above operations being determined by the depth of the working and the kind of material which is to be kept out of the working parts. Various ill effects and even death itself arise from these occupations. The chief effects are the following—viz. oozing of blood from mouth or nose, rupture of tympanum or tympani, muscular pains and swellings of limbs and joints, vomiting, headache, giddiness, and paralysis of lower limbs, sensory and motor, which manifest themselves on decompression. For further information the reader is referred to Snell's work on "Compressed Air Illness," which, besides giving a full account of his experiences during the construction of the Blackwall Tunnel, London, includes the bibliography of the subject. (*Vide* also p. 101.)

The student who desires to pursue the subject in greater detail is referred to the works of Arlidge, Oliver, and others on trade-diseases.

Occupational Mortality.—The latest returns for England and Wales are based on the Census-returns of 1901, and the deaths of males actually employed or on the retired list during 1900-1902. In previous returns the statistics related exclusively to those who, at time of enumeration, were found to be following a definite employment. The returns for 1901 include for the first time persons on the retired list. The tables in these returns are, however, so arranged that one series relates to the occupied only, to enable comparisons to be made with previous returns, and a second series relates to the retired as well as to the occupied. The 1901 returns omit certain occupations owing to indefiniteness of statement of occupation either in the Census-returns or in the death-registers. These are (1) mine-service, (2) artisan, mechanic; and (3) factory labourer. Other occupations have been, however, added; these being domestic coachman, groom, tramway-service, coal and coke merchant or dealer, lithographer, copper and steel plate printer, furrier, skinner, cycle and motor manufacture, civil service officers and clerks and messengers, etc., gamekeeper, india-rubber and gutta-percha worker, waterproof goods maker, brush and broom maker, hair and bristle worker. In working out the details of these returns, it was necessary to ascertain for each occupation (*a*) the numbers living in 1901, and (*b*) the numbers dying in the three years, 1900-1902. The Census-returns provided the first, the death-registers the second. The tables in the 1901 return show the number of deaths under 24 separate headings at seven age-groups, the particulars of diseases and ages being the same as those in the previous returns. From the years of life, and from the recorded deaths in 1900-1902, the mean annual death-rates per 1000 for the seven groups of ages were calculated, these affording the means of comparing the age-incidence of mortality in one occupation with any other occupation and with males generally. The interval of life chosen for inquiry was that between 25 years and 65 years of life, that period or interval representing better, perhaps, than any other period the effective working part of life. For this period a "comparative mortality figure" was worked out.

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[1] *British Med. Jour.*, 1887, vol. i., p. 343.

In the three years (1900-1902) the crude death-rate among all males aged 15 and upwards was 16·23, and the number of registered deaths of males between 25 and 65, 284,009, these 284,009 deaths occurring in the course of 20,166,153 years of life—a number equal to three times the population enumerated at these ages at the Census of 1901. Within the age-limits 25-65, 1000 deaths occurred annually among 71,005 living. If the number 71,005 be divided proportionately to the numbers enumerated at that Census in the four decennia, the number 26,259 were living at 25-35 years, 20,407 at ages 35-45, 14,748 at ages 45-55, and 9591 at ages 55-65. This number, 71,005, is the figure adopted as the "standard population," which, subject to the mortality-rates prevailing in these several age-groups among males generally, produced 1000 deaths annually. If the four constituent numbers just given be multiplied by the death-rates recorded at the corresponding age-groups, 25-35, 35-45, 45-55, and 55-65, in each occupation, the sum of the products will give the number of deaths which would occur in the standard population, supposing that population to have had the same death-rates as prevailed in that occupation. The figure so obtained is the "comparative mortality figure," for the occupation in question.

The following table is given as an example :—

TABLE XLIX

Age-Periods	Standard Population 1	All Males		Occupied Farmers	
		Annual Death-rate per 1000 2	Deaths in Standard Population 3	Annual Death-rate per 1000 4	Deaths in Standard Population 5
25–35 years	26,259	6·38	168	3·96	104
35–45 ,,	20,407	10·94	223	5·66	116
45–55 ,,	14,748	18·67	275	10·05	148
55–65 ,,	9,591	34·80	334	20·25	194
25–65 years	71,005	—	1000	—	562

In the same way, corresponding figures were calculated both for the occupied only and for the occupied and retired in each occupation. In order to find how much of the comparative mortality figure for a given occupation was due to each of the causes in the abstracts in the returns, the Registrar-General adopted the following plan. The part of the mortality-figure which was contributed by each of the four age-periods between 25 and 65 was divided in proportion to the numbers of deaths from the several causes in that age-period; for example, the 168 deaths in the foregoing table contributed by the age-period 25-35 to the comparative mortality figure for all males was divided in proportion to the numbers of deaths from the several causes. As the total of these numbers was 47,608, they were severally reduced in the proportion of 168 to 47,608; and so in the same way for the other columns.

Between 1890-1892 and 1900-1902, the Registrar-General found that there had been a considerable decline in the general mortality throughout the main working period of life. The following table shows this clearly :—

TABLE L

	25-	35-	45-	55-65
Death-rates per 1000—1890–1892	7·67	13·01	21·37	39·01
,, ,, ,, —1900–1902	6·38	10·94	18·67	34·80
Death-rate in 1900–1902 compared with that in 1890–1892 taken as 100	83	84	87	89

The decline in proportions varied from 11 per cent. at 55-65, to 17 per cent. at 25-35.

So great were the changes of mortality that, whereas in 1890-1892 1000 deaths occurred annually among 61,215 males living between 25-65 years, in 1900-1902, 1000 deaths occurred among 71,005 living at same ages; so that, ignoring change of age-constitution, the population which gave 1000 deaths in the former period would have given 1160 deaths in the latter had the same rates obtained. But it was found that the age-constitution had changed in a manner slightly favourable to the latter and more recent period.

In the Report for 1890-1892, the comparative mortality figures were calculated on the standard population of that time, but in the Report for 1900-1902 these figures for 1890-1892 have been recalculated by applying the death-rates in those years to the standard population in 1900-1902, similar to the method described for obtaining comparative figures for the several occupations.

To obtain anything like reliable results, no inconsiderable difficulties have to be met and, if possible, overcome. Among others the Registrar-General mentions the following :—

1. To determine rates of mortality for several grades of workers, it was necessary to compare the entries of occupation in the Census-schedules with those in the death-registers, since the records might be affected erroneously owing to the fact that in the former the entries having been made by the workers themselves, and in the latter by a friend or relative, no other remedy could be found for such possible discrepancies of description.

2. The date of the Census (1st April 1901) was earlier by three months than the middle of the three-year period to which the deaths refer. It had to be decided, therefore, to calculate the mortality on the Census-population of 1st April 1901, and on the deaths in the three years 1900-1902, the error thereby resulting being so small as to be negligible.

3. Paucity of numbers of workers in certain occupations. Here the risk of error was got over by grouping allied occupations containing small numbers ; although in some instances, *e.g.* miners in lead, in tin, and in copper, separate figures are given, these must be used with great caution.

4. Choice of occupation due to physical fitness of workers ; thus, weaker persons are apt to select less arduous occupations, and persons unfitted by physical disability to follow an active occupation are attracted to sedentary occupations.

5. Relative healthiness of different industries—the more exacting and strenuous demanding picked lives.

These two last-named factors must always be carefully considered in relation to occupational mortality, because there cannot be any form of statistical correction.

The following table shows—

TABLE LI

Death-rates per 1000 *among all Males at Seven Age-Groups in Four Periods*

Period	15-	20-	25-	35-	45-	55-	65 up
1860–61–1871	6·32	8·59	9·25	13·05	18·53	32·15	94·43
1880–1882	4·57	6·04	8·16	12·73	19·27	33·84	92·65
1890–92	4·14	5·55	7·67	13·01	21·37	39·01	103·56
1900–02	3·49	4·77	6·38	10·94	18·67	34·80	94·61

Decline in mortality in pulmonary phthisis between 1890-1892 and 1900-1902 has been shown in most occupations, but it has remained stationary among messengers, inn servants, tanners, lace and hosiery workers, lead workers ; and there has been a considerable rise among general shopkeepers, cutlers, ironstone, copper, and tin miners, general labourers, inn servants in industrial districts, innkeepers in agricultural districts, and unoccupied males.

TABLE LII

Showing the Comparative Mortality Figures in 1880-1882, 1890-1892, *and* 1900-1902, *for Different Occupations*

Occupation	Comparative Mortality Figures Calculated on Two Age-Groups		
	1880-1882	1890-1892	1900-1902
All Males	1089	1155	1000
Clergy, priests, ministers	604	630	538
Gardeners, etc.,	652	655	543
Farmers	686	681	585
Agricultural labourers	763	787	567
Schoolmasters and teachers	782	660	583
Grocers	839	767	666
Fishermen	869	974	895
Carpenters and joiners	892	899	775
Stationers, publishers, newsagents	899	954	863
Barristers, solicitors	915	947	729
Drapers, warehousemen	963	1137	730
Coal-miners (mean of several districts)	968	1037	803
Plasterers, whitewashers, and paper-hangers	974	1237	933
Watch and clock makers	1014	1117	801
Tanners	989	867	728
Carriers, etc.	985	1135	941
Shoemakers	1003	1073	916
Artists, sculptors, engravers, architects	1002	897	753
Commercial travellers	1031	1070	878
Millers, etc.	1040	973	849
Confectioners	1042	1045	837
Builders, bricklayers, and masons	1055	1156	858
Blacksmiths, and strikers	1059	1049	883
Tobacconists	1091	1157	892
Chemists and druggists	1106	1058	922
Tailors	1145	1153	950
Printers	1167	1211	903
Bookbinders	1271	1206	866
Operators in wool and worsted mills (West Riding)	1122	1139	917
Operatives in linen and cotton mills (Lancashire)	1182	1296	1010
Medical practitioners	1222	1106	962
Law-clerks	1252	1188	846
Butchers	1276	1232	1027
Glass-blowers, etc.	1295	1652	1161
Plumbers, painters, glaziers	1308	1261	1021
Cutlers, scissors, saw, tool and needle makers	1424	1735	1468
Carriers, carmen	1387	1441	1052
Bargemen, lightermen, and watermen	1422	1379	1237
Musicians and music-masters	1431	1370	1125
Hairdressers	1446	1237	1017
Brewerymen	1483	1625	1310
Maltsters	902	999	721

Occupation	Comparative Mortality Figures Calculated on Two Age-Groups		
	1880-1882	1890-1892	1900-1902
All Males	1089	1155	1000
Chimney sweeps	1652	1525	1292
Innkeepers, licensed victuallers	1661	1938	1709
Messengers, porters, watchmen	1707	1420	1358
Filemakers	1813	2070	1609
Earthenware manufacturers, potters	1890	1891	1372
Ironstone miners	908	863	712
Tin miners (Cornish)	1996	1620	2160
Costers, hawkers, etc.	2048	1942	1790
General labourers (London)	2220	1617	1816
Labourers (agricultural)	763	787	567
Inn and hotel servants	2402	1884	1679
Innkeepers and servants	1764	1925	1705
Unoccupied Males	2349	2707	3082
Fishermen	869	974	895
Hatters	1159	1259	1019
Tallow, soap, glue, manure, etc. manufacturers	1012	1295	676
Tinplate manufacturers	961	1108	956
Silk, satin, and crape manufacturers	920	1102	931
Lace makers	820	821	832
Dyers, finishers, bleachers, and printers of textiles	1100	1560	1041
Carpet, rug, and felt makers	1030	1038	929
Hosiery makers (Leicester and Nottingham)	730	845	862
Paper makers	780	1010	664
Glass makers	1295	1652	1161
Coal heavers	1055	1716	1135
Platelayer, railway labourer, navvy, and road labourer	1118	1231	716

Note.—The figures of the foregoing table afford a means of comparison of the mortality of any occupation named in the three periods: they are not intended as a comparison between the different occupations. The figures given under the periods 1880–1882 and 1890–1892 differ from those published in previous tables of the Registrar-General. In each of the previous reports for these respective periods, the standard population adopted was the population which gave 1000 deaths according to the rates of mortality prevailing in these respective periods. For each succeeding period it was necessary to recalculate the earlier figures, so as to make allowance for changes in mortality-rates and changes of age-constitution between the different periods. With every change of standard population revision is necessary, if comparability is desired for the figures in the several periods. Whether the standard population of 1890–1892 or that of 1900–1902 should be adopted, is a question of doubt, but in the foregoing table the figures have been calculated on the standard population of 1900–1902. If the standard population of 1890–1892 had, instead, been adopted, the figures given in this table for 1900–1902 would have been one-ninth part less than those given.[1]

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[1] Supp. Sixty-Fifth Annual Report, Registrar-General for England, Part II., 1908.

The latest figures relating to occupational mortality in Scotland are published in the supplement to the Forty-Eighth Report of the Registrar-General for Scotland. They are based on the Census-population of 1901 and on the registered deaths of 1900–1902. In this report a departure was made from the method adopted in previous similar reports, in respect that no comparative mortality figures were either calculated or published. Instead, a new plan was introduced. In place of comparing the mortality of the various occupations by comparative mortality figures, calculations were made of the probable errors of the death-rates, and the occupations were divided into six groups according to whether their death-rates were greater or less than, or not decidedly different from, those of all males in each of two periods. In order to overcome, so far as possible, the probable error arising out of paucity of numbers—a circumstance more likely to arise in Scotland than in England—the following formula was adopted—

$$\text{Death-rate per 1000} = \left(\frac{n}{N} \times 1000\right) \pm \left(\frac{\cdot 67449}{N}\sqrt{\frac{n.m}{N}} \times 1000\right).$$

where N = population ; n = deaths ; m = population *minus* the deaths.

The mortality arising from any occupation depends upon the following factors—viz. (1) the initial fitness of the employee for the occupation pursued ; (2) the nature of the occupation ; (3) the environment of the employment ; and (4) habits of a vicious character which may be contracted by the workman. At the very outset it should be stated that the foregoing tables have been compiled from the mortality-returns, and from the information supplied at death-registration as to the occupation of the deceased, and on the assumption that the occupation named has been followed during the whole life-time of the deceased. It is obvious that some measure of error may creep in at this stage, since it not infrequently happens that the occupation given has not always been that of the deceased. For example, certain occupations as innkeeping, liquor-selling, shop-keeping, and others have attractions for men who have saved money in their original calling, but in which, it may be, their health has broken down ; hence the mortality is debited to the last-named occupation, while, more properly, it ought to be debited to the original. The given mortality-rate of a given occupation may not, therefore, be the result solely of the conditions of that occupation, but is likely to be partly due to that, and to the previously depreciated health derived from a former occupation, or defective physique which has existed initially. Another cause which militates against the accuracy of such returns is that many occupations, because of their light and easy character, attract the initially weak, disabled, or deformed. This is true, for example, of such employments as clerk, tailor, watchmaker, and others in which much physical exertion is not required. Subject to these considerations, therefore, the mortality-rates given in the preceding tables may be taken as sufficiently accurate to make it possible to compare the relative incidence of the death-toll of occupations.

But short of producing death, certain occupations produce a physical deformity or disability. These need not be elaborated, since a glance at the following table will show illustrative examples.

[TABLE

TABLE LIII

Occupations which Cause Physical Deformity or Disability

Occupation	Deformity or Disability	Proximate Cause
Boiler-Makers, Riveters, or Workers amid concussive noises, Caisson-Workers.	Deafness.	Repetitive Concussion of Tympanum of Ear, Rupture of Tympanum.
Shoemakers.	Indentation of Sternum.	Pressure of the Last.
Tailors.	Peculiar Gait in Walking.	Turk-like Attitude of Lower Limbs when at Work.
Clerks, Students, Scholars, and sedentary workers generally.	Lateral Curvature of Spine.	Faulty Posture of Body.
Telegraphists, Stenographers, Instrumentalists.	Muscular Cramp of Fingers or Hand.	Continuous Strained Use of Digit Muscles.
Clergy (Preachers).	Affections of Throat and Voice.	Unnatural Use of Muscles of Larynx.
Miners, Jewellers, Watchmakers, Scientific Instrument Makers, Microscopists, Seamstresses, Engravers.	Affections of Eye and Vision.	Strain on Visual Apparatus.
Cooks, Gardeners, Car and 'Bus Conductors, Shopkeepers, and persons generally who continuously stand at work.	Varicose Veins and Ulcers of Lower Limbs, Varicocele.	Congestion of Veins from Effect of Gravity and Muscular Strain on Limbs.
Soldiers, Athletes, Porters, Dock-Labourers, etc.	Hernias; Diseases of Heart and Large Arteries, as Aneurysms.	Strain on Circulatory System; Great Muscular Effort.
Bridge-pier Builders (in caissons), Divers, Workers under compressed air.	Diseases of Circulation and Nervous System.	Abnormal Atmospheric Pressure.

An obligatory duty has been imposed upon the medical practitioner with respect to occupations, which cannot be neglected without a penalty—viz. the notification to the Home Office (Factory Department) in England, of certain forms of industrial poisoning and disease directly incurred by workmen during their occupation. The Factory and Workshop Act, 1895, section 29, enacts that it is compulsory for medical practitioners to notify every case of lead, arsenic, phosphorus, or mercurial poisoning, and of anthrax, which is contracted in a factory or workshop. The fulfilment of the duty carries with it a fee of 2s. 6d. for each certificate. The institution of the above provision has proved of immense value to the Factory Department of the Home Office, and much valuable information may be obtained from the Annual Reports on this subject.

No chapter on the Diseases of Occupations could be considered complete without some detailed reference to Factory and Workshop legislation. Formerly this was a serious task to undertake, because of the many Acts of Parliament which bore upon the subject. This bewildering wealth of legislative enactments, however, brought about a remedy by the Legislature itself—viz. the passing of a Consolidating Act—the **Factory and Workshops Act, 1901** (1 Edw. VII. cap. 22)—which came into operation on 1st January, 1902, and in which practically all previous legislation respecting Factories and Workshops has been welded into a harmonious whole. Medical practitioners who act or who may yet act under its terms as Certifying Surgeons, and Medical Officers of Health who have to deal with the sanitary aspects of the Act, are, therefore, interested in its consideration.

The Act is divided into ten Parts, and each Part into a varying number of Sections.

Part I. deals with the *health* and *safety* of those employed, and with *accidents* ; Part II., with *conditions of employment* with respect to hours and holidays, overtime, night work, intermittent employment, powers of the Secretary of State to impose special sanitary requirements under special circumstances as a condition of employment, and fitness of employment of women, young persons, and children; Part III., with the education of children employed in factories ; Part IV., with *dangerous* and *unhealthy industries* and the Regulations to be made concerning these ; Part V., with *tenement factories*, *Cotton Cloth* and *other humid Factories*, *Bakehouses*, *Laundries*, *Docks*, *Buildings* and *Railway Sidings* ; Part VI., with *Home Work*, with respect to outworkers in certain trades, employment of persons in unwholesome places, making of wearing apparel where there is scarlet fever or smallpox, and to dangerous processes in domestic factories and workshops; Part VII., with work and wages, with respect to wages for piece-work, and inspection of weights and measures upon which rates of wages are based; Part VIII., with administration of the provisions of the Act ; under Sections 122, 123, and 124 with special reference to the appointment and duties of Certifying Surgeons and their remuneration ; under Section 132, with respect to Reports of Medical Officers of Health on Administration of the Act ; and Section 133, with notice to be given by the Medical Officer of Health of employment of a woman, young person, or child, when he becomes aware that such is being employed in a workshop in which no abstract of this Act is posted up in a public place in the work as required by the Act ; Part IX., with *Legal Proceedings* ; and Part X., with the *application* and *definitions* of the Act with relation to the different parts of the United Kingdom.

Factories which come under the Act are divided into two sections—viz. (A) all places in which mechanical power is used in aid of manufacturing processes ; and (B) all places named in Part I. of the Sixth Schedule of the Act, whether mechanical power is used or not. The list of industries named in this Schedule contains the following—viz. print-works, bleaching and dyeing works, earthenware-works, lucifer-match works, percussion-cap works, cartridge works, paper-staining works, fustian-cutting works, blast furnaces, copper mills, iron mills, foundries, metal and india-rubber works, paper mills, glass works, tobacco factories, letter-press printing works, bookbinding works, flax scutch mills and electrical stations.

Workshops include (A) such industries as are named in Part II. of the Sixth Schedule—viz. hat works, rope works, bakehouses, lace warehouses, shipbuilding yards, quarries, pit banks of metalliferous mines, dry-cleaning works, carpet-beating works, and bottle-washing works, unless mechanical power is used in aid, when they become factories; (B) any other premises in which manual labour is exercised for trade or purposes of gain, and to or over which the employer of the workers has right of access or control; and (C) any work-place—called in the Act a *tenement workshop*—in which two or more persons with the permission of or under agreement with the owner or occupier carry on work. Laundries do not come within the foregoing definitions; but by Section 103, so far as sanitation is concerned, they are to be treated as factories if mechanical power is used, and as workshops if such power is not used. Laundries in connection with prisons, reformatory schools, industrial schools, or any other institution subject to inspection under other Acts, and which are worked by the inmates thereof, are exempted from the provisions of this Act. In like manner are laundries which are worked by members of one family and by not more than two persons outside of the family. The term *work-place*, although not defined in this Act, may be reckoned to come under the interpretation of the word in the Public Health (London) Act, 1891, which was given in Bennett *v.* Harding, 1900 (2 Q. B. 397)—viz. any "place where work is done permanently and where people assemble to do work permanently of some kind or other"; such as restaurant-kitchens and like places.

Duties of Medical Officer of Health under this Act.—The Medical Officer of Health is charged with the duty of administering the Act in Workshops and Work-places with respect to their sanitary condition. The term "sanitary condition" of a workshop may be held to include (a) *Cleanliness*, (b) *conditions of Air-space*, (c) *Ventilation*, and (d) *Drainage of Floors.*

For these purposes, sec. 91 of the Public Health (England) Act, 1875, sec. 15 of the Public Health (Scotland) Act, 1897, and sec. 107 of the Public Health (Ireland) Act, 1878, apply respectively in these divisions of the kingdom. Cleanliness is to be interpreted to mean a place in a cleanly state and free from effluvia; air-space, not less than 250 cubic feet of air-space per person employed, or 400 cubic feet per person during overtime. Where a place is used as a workshop or work-place during working hours, and a sleeping-place at night, it is proposed to enact that the minimum air-space shall be 400 cubic feet. Ventilation is to be held to mean the existence or provision of such means for changing the air as to render harmless so far as practicable any gases, vapours, dust or other impurities, generated in the course of the work that are a nuisance or are injurious to health. Drainage of floors means that where in any process in which women are employed the floor is liable to be wetted, provision must be made for draining off the fluid. This does not apply in the case where men only are employed. Sanitary conveniences must be provided in any district in England where Part III. of the Public Health Amendment Act, 1890, is in force. (*Vide* also p. 237.)

Bakehouses are either factories or workshops in terms of the Act, according as mechanical power is or is not used therein. Sanitary regulations for bakehouses are contained in Sections 97, 98, 99, 100, 101, and 102. These are (1) that a water-closet, earth-closet, privy, or ash-pit must not be within or communicate directly with the bakehouse; (2) that the cistern for the water-supply must be separate and distinct from any cistern supplying a water-closet; (3) that a drain or pipe conveying fæcal or sewage matter must not have an opening within the bakehouse; (4) that all the walls, ceilings, tops of rooms, passages, and staircases of a bakehouse (whether plastered or not) must either be painted with oil paint or be varnished with three coats, or be limewashed, or treated with one or other of these methods combined; if painted or varnished, the whole place must be washed once every six months, and the painting or varnish to be renewed in three coats once every seven years, and if limewashed, the limewashing to be renewed once every six months; (5) no apartment on the same level as the bakehouse and forming part of the same building may be used as a sleeping-place, unless it is separated by a partition which extends from floor to ceiling, and has an external glazed window of at least nine superficial feet in area, of which at least one-half of said window-space is made to open for ventilation. No *underground bakehouse* may be instituted after this Act has come into operation, and after 1st January 1904, any underground bakehouse existing as such at the commencement of the operation of the Act may not be used unless a certificate of suitability in respect of construction, light, ventilation, etc., has been obtained.

An underground bakehouse means one in which the surface of its floor is more than three feet below the level of the footway of the street or of the ground adjoining or nearest the bakehouse apartment. The proposals of the Incorporated Society of Medical Officers of Health on this subject of underground bakehouses are as follow:—1. That bakehouses shall be at least 8 feet in height, or 8 feet 6 inches where the floor area exceeds 300 square feet; 2. That the walls and floor shall be constructed of impervious materials, that the ceilings shall be dust-proof, and that the lighting shall be such that a printed paper may ordinarily be read by daylight between 11 A.M. and 3 P.M.; 3. That the ventilation shall be such that 3000 cubic feet of clean air can be supplied to each person employed therein; and 4. That the temperature of the bakehouse between October and June shall not exceed 60° F. Among the further necessary provisions proposed were:—(*a*) that there shall be free access to sanitary conveniences, and to conveniences for personal ablution, (*b*) provision for depositing wearing apparel elsewhere than in the bakehouse, and (*c*) that all baking-troughs, tables, etc., be mounted on castors for easier cleansing of the bakehouse. The report of *The Lancet* Special Sanitary Commission on Bakeries and Breadmaking will afford to the student some interesting information.[1]

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[1] *Lancet*, vol. ii., 1889, p. 1140.

A *retail bakehouse* is any bakehouse, not being a factory, in which the goods manufactured therein are sold by retail in a shop or place occupied with the bakehouse.

For the sanitary condition of factories the Factory Inspector is held responsible, but by section 5, sub-section 2, he may take with him into a factory or workshop a medical officer of health or inspector of nuisances. Home-work—that is, where work is done for a factory or workshop at home—is dealt with in Sections 107–115. Lists of out-workers, giving names and addresses, must be kept by occupiers of factories or workshops. The Act aims at preventing (1) home-work being done in dwellings injurious or dangerous to the health of the workers themselves, and (2) work being done in premises where exists dangerous infectious disease. When infectious disease is discovered to exist in a home so used, the contractors or occupiers of the factory or workshop may be prohibited from giving out work to any person who lives or works in the infective house.

Duties of Certifying Surgeon under the Act—Section 122.—The appointment of Certifying Surgeons is made by the Secretary of State for the Home Department. A surgeon who is occupier of a factory or workshop, or who is directly or indirectly interested therein, shall not be Certifying Surgeon for that factory or workshop. A Certifying Surgeon shall conform to such regulations and duties of the office as are made and assigned by the Secretary of State. He shall, if so directed by the Secretary of State, make any special inquiry and re-examine any young person or child. He shall in each year, at a prescribed time, make a Report in prescribed form to the Home Office as to the persons inspected during the year, and the results of the inspection. A poor-law Medical Officer may act as Certifying Surgeon to a factory or district in which for the time being there is no duly appointed Certifying Surgeon. The fees to be paid to a Certifying Surgeon for the examination and granting of certificates of fitness for employment of young persons and children are regulated in Section 124 as follows—viz. (*a*) the factory occupier may agree with him as to the amount to be paid; or (*b*) where there is no agreement, the fees shall be paid in accordance with the scale set down in Part I. of the Fifth Schedule of the Act, or with any other scale substituted therefor by the Secretary of State. The fees are to be paid when the examination is completed or a certificate is granted, or at any other time directed by an Inspector. The fee to be paid to him for the investigation of an accident in pursuance of the Act shall be a sum not less than three and not more than ten shillings, as prescribed by the Secretary of State, and shall be paid by the Secretary of State. It is enacted in Section 20 that the Certifying Surgeon, on receipt of notice of an accident in a factory or workshop, shall proceed with the least possible delay and make a full investigation, and shall within twenty-four hours thereafter send a report thereof to the Inspector.

Ages and Conditions of Employment of Employees.—The employment of any woman or girl, within four weeks after she has given birth to a child, is prohibited by Section 61; the employment of any child under twelve years, in Section 62; and Sections 63, 64, and 65 deal with certificates of fitness for employment of young persons under sixteen and of children in factories, and with the regulations to be observed by the Certifying Surgeon in granting such certificates. Section 66 gives power to the Secretary of State to require by special order certificates of fitness for employment of such young persons, etc., in certain workshops; and Section 67, power to an Inspector to require a certificate of capacity for work of any young person or child, where he is of opinion that such young person or child is incapacitated by disease or bodily infirmity for working daily for the time allowed by the Act.

Duties of Medical Practitioner in notifying certain Diseases contracted in a Factory or Workshop.—Section 73 supplants Section 29 of the former Act of 1895 regarding notification of certain diseases contracted by a worker in a factory or workshop. The terms of this section are as follow—viz.

1. "*Every medical practitioner attending on or called in to visit a patient whom he believes to be suffering from* lead, phosphorus, arsenical or mercurial poisoning, or anthrax, *contracted in any factory or workshop, shall (unless the notice required by this sub-section has been previously sent) send to the Chief Inspector of Factories at the Home Office, London, a notice stating the name and full postal address of the patient and the disease from which, in the opinion of the medical practitioner, the patient is suffering, and shall be entitled in respect of every notice sent in pursuance of this section to a fee of two shillings and sixpence, to be paid as part of the expenses incurred by the Secretary of State in the execution of this Act.*

2. "*If any medical practitioner, when required by this section to send a notice, fails forthwith to send the same, he shall be liable to a fine not exceeding forty shillings.*

3. "*Written notice of every case of lead, phosphorus, or arsenical or mercurial poisoning, or anthrax, occurring in a factory or workshop, shall forthwith be sent to the inspector and to the certifying surgeon for the district; and the provisions of this Act with respect to accidents shall apply to any such case in like manner as to any such accident as is mentioned in these provisions.*"

In view of the desire of the Legislature that such noxious conditions should be repressed, various provisions are to be found in the Act towards their prevention. It is enacted in Section 74 that in a factory or workshop where grinding, glazing, or polishing on a wheel, or any process is carried on by which dust, gas, vapour, or other impurity is generated and inhaled by the workers to an injurious extent, that ventilation by means of a fan or other mechanical means shall be provided, maintained, and used; in Section 75, that in every factory or workshop where lead, arsenic, or any other poisonous substance is used, suitable washing-conveniences must be provided for the workers; that no employee shall be permitted to take a meal, or be allowed to remain during meal-hours, in any room in which such poisonous substances are used, and suitable provision shall be made elsewhere in the factory for meal-taking. In Section 76, it is further enacted that no young person under sixteen years, or a child, shall be employed (*a*) in the process of silvering mirrors by the mercurial process; and (*b*) in the making of white lead; no female young person or child in the process of making or annealing glass ; no girl under sixteen years, (*a*) in making or finishing bricks or tiles, not being ornamental tiles ; and (*b*) in the making or finishing of salt ; and no child, in (*a*) dry grinding in the metal trade ; and (*b*) the dipping of lucifer matches. Provision is made in the following section (Section 78) prohibiting the taking of meals by women, young persons, or children in certain parts of factories and workshops, as for example : (*a*) in glass-works, in places where the materials are mixed, or where flint glass is made, or where grinding, cutting, or polishing is carried on ; (*b*) in lucifer-match works, in any part except where the wood is cut ; and (*c*) in earthenware-works, in places known as dipper's house, dipper's drying-room, or china scouring-room. In all cases, notice of the above prohibitions must be affixed in every factory or workshop to which they apply.

The only further legislation regarding factories and workshops is contained in the **Factory and Workshops Act, 1907.**

This Act amends the Act of 1901 with respect to laundries, extends that Act to certain institutions, and provides for the inspection of certain premises.

Section 1. Enacts that the Act of 1901 shall, subject to the provisions of this Act, apply to laundries as if at the end of Part II. of the Sixth Schedule to that Act, the following paragraph were added :—

"(29) Laundries carried on by way of trade or for the purpose of gain, or carried on as ancillary to another business or incidentally to the purposes of any public institution."

Section 2. (1) In laundries, other than laundries ancillary to a business carried on in any premises which, apart from the provisions of this Act, are a factory or workshop—

(*a*) The period of employment of women may on any three days in the week, other than Saturday, begin at 6 A.M. and end at 7 P.M., or begin at 7 A.M. and end at 8 P.M. or begin at 8 A.M. and end at 9 P.M. ;

Provided that a corresponding reduction is made in the periods of employment on other days of the week, so that the total number of hours of the period of employment of women, including the intervals for meals, shall not exceed 68 in any one week ;

(*b*) Where the employer so elects, the following provisions shall apply in lieu of the provisions of the preceding paragraph :—

The period of employment of women may, on not more than *four days*, other than Saturday, in any one week, and on not more than 60 days in any calendar year, begin at 6 A.M. and end at 7 P.M., or begin at 7 A.M. and end at 8 P.M., or begin at 8 A.M. and end at 9 P.M.

(*c*) Different periods of employment may be fixed for different days of the week.

(2) The foregoing provisions of this section shall be deemed to be special exemptions within the meaning of Section 60 of the Act of 1901, but it shall be lawful for the employer to change from the system of employment under the above paragraph (*a*) to the system under paragraph (*b*), or *vice versa*, oftener than once a year. The entry required to be made in the prescribed register by sub-section 4 of Section 60, as so

applied shall, in the case of overtime employment under paragraph (*b*), be made before the commencement of the overtime employment on each day on which it is intended that there should be such employment, and, in reckoning the sixty days for the purposes of paragraph (*b*), every day on which any woman had been employed overtime shall be taken into account.

(3) Subject as aforesaid, the provisions of the principal Act as to hours of employment shall apply to laundries.

Section 3. Enacts that in every laundry—

(*a*) If mechanical power is used, a fan or other efficient means shall be provided, maintained, and used for regulating the temperature in every ironing-room, and for carrying away the steam in every wash-house ;

(*b*) All stoves for heating irons must be sufficiently separated from any ironing-room or ironing-table, and gas irons emitting any noxious fumes must not be used ; and

(*c*) The floors must be kept in good condition and drained in such a manner as will allow the water to flow off freely.

A laundry in which there is a contravention of any of these provisions shall be deemed to be a factory or workshop not kept in conformity with the principal Act.

Section 4. Enacts that sub-section 2 of Section 114 of the Act of 1901 shall apply to laundries, as if for the words " the altering, repairing, ornamenting, or finishing of any article" there were substituted the words, " the altering, repairing, ornamenting, washing, cleaning, or finishing of any article."

Institutions

Section 5. (1) Enacts that where in any premises forming part of an institution carried on for charitable or reformatory purposes, and not being premises subject to inspection by or under the authority of any Government Department, any manual labour is exercised in or incidental to the making, altering, repairing, ornamenting, finishing, washing, cleaning, or adapting for sale, of articles not intended for the use of the institution, the provisions of the Act of 1901 shall, subject to the provisions of this Act, apply to those premises, notwithstanding that the work carried on therein is not carried on by way of trade or for the purposes of gain, or that the persons working therein are not working under a contract of service or apprenticeship.

(2) If in any institution to which this section applies the persons having the control of the institution (the managers) satisfy the Secretary of State that the only persons working therein are persons who are inmates of and supported by the institution, or persons engaged in the supervision of the work or management of machinery, and that such work is carried on in good faith for the purposes of the support, education, training, or reformation of persons engaged in it, the Secretary of State may by order direct that so long as the order is in force the Act of 1901 shall apply to the institution subject to the following modifications :—

(*a*) The managers may submit for the approval of the Secretary of State a scheme for the regulation of hours of employment, intervals for meals, and holidays of the workers, and of the education of children, and if the Secretary of State is satisfied that the provisions so laid down are not less favourable than the corresponding provisions in the principal Act, he may approve the scheme, and when so approved, the principal Act shall apply as if the provisions of the scheme were substituted for the like provisions of the principal Act. Any such scheme shall be laid before Parliament, and if within the next forty days thereafter either House resolve that the scheme should be annulled, the scheme shall be of no effect.

(*b*) The Medical Officer of the institution (if any) may, on application of the managers, be appointed by the Chief Inspector of Factories to be the Certifying Surgeon for the institution.

(*c*) The provisions of Section 128 of the principal Act as to affixing of an abstract of the principal Act and of notices shall not apply, but among the particulars to be shown in the general register there shall be included the prescribed particulars of the scheme, or in the absence of a scheme, the prescribed particulars as to hours of employment, intervals for meals, and holidays, and education of children and other matters dealt with in the principal Act.

(*d*) In the case of premises forming part of an institution carried on for reformatory purposes, and where the managers thereof so give notice to the Chief Inspector of Factories, an Inspector shall not, without consent of the managers or person in charge, examine an inmate of the institution save in the presence of one of the managers or of such person in charge;

Provided that the Secretary of State, on being satisfied that there is reason to believe that a contravention of the principal Act is taking place in any such institution, may suspend the operation of the foregoing provision as respects that institution.

(*e*) The managers, not later than 15th January in each year, shall send to the Secretary of State in the prescribed form a correct return, giving names of managers and of the person in charge, and such particulars as to number, age, sex, and employment of inmates and other persons employed in the work carried on in the institution as the Secretary of State may require, subject to a fine in case of non-compliance.

Section 6. Enacts that where in any premises subject to inspection of any Government Department any manual labour is exercised, otherwise than for purposes of instruction in or incidental to the making, altering, repairing, ornamenting, finishing, washing, cleaning, or adapting for sale of any article, and the premises do not constitute a factory or workshop by reason that the work carried on therein is not in the way of trade or for gain, or that the persons employed are not working under contract of service or apprenticeship, the Secretary of State may arrange that such premises shall, as respects matters dealt with by the principal Act, be inspected by an Inspector appointed under that Act.

Section 7. Repeals Section 103 of the Act of 1901.

In connection with the subject of industrial diseases, attention must be drawn to the Act of Parliament entitled "**White Phosphorus Matches Prohibition Act, 1908**" (8 Edw. VII. ch. 42), which is an Act to prohibit the manufacture, sale, and importation of matches made with white phosphorus, and for other purposes in connection therewith. The following, put briefly, are its provisions :—**Section 1.** Makes it unlawful for any person to use white phosphorus in match-manufacture, and any factory in which it is used shall be deemed as a factory not in conformity with the Factory Act, 1901; the occupier of any match-factory shall allow an inspector under the Factory Act, 1901, at any time to take for analysis samples of any material used in his factory, and on his refusal, shall be guilty of obstructing the inspector in the execution of his duties under that Act; provided that, when any such sample is so taken, and on providing the necessary appliances, the occupier may require the inspector to divide the sample into two parts, and to mark, seal, and deliver to him one part. **Section 2.** Forbids any person to sell, or to offer or expose for sale, or to have in his possession for purposes of sale, any matches made with white phosphorus; and on contravention he may, on complaint to a Court of summary jurisdiction, be ordered to forfeit such matches, which shall be destroyed or otherwise dealt with as the Court may determine, but this provision shall not come into operation as respects retail dealers until 1st Jan., 1911. **Section 3.** Forbids the importation into the United Kingdom of any matches so made. **Section 4.** Enables any manufacturer who is making or is proposing to make matches, to present a petition to the Board of Trade praying for a compulsory licence to use any process patented at the passing of this Act for the making of matches without white phosphorus, other than matches intended to strike only on a specially prepared surface, and the Board of Trade may order the patentee to grant such licence on such terms as the Board may think fit.

For the purposes of this Act, the expression "white phosphorus" means the substance usually known as white or yellow phosphorus.

APPENDIX I

THE **Anthrax Order of 1899** has been superseded by the **Anthrax Order of 1910** (7989), which was issued by the Board on 24th September, 1910, and which comes into operation on 1st January, 1911.

Summarised, the provisions of the Articles of the new Order are as follow :—

Article 1. Deals with interpretations of expressions used in the Order.

Article 2. Deals with the notice to be given of disease. (1) Every person possessing or having under his charge a diseased or suspected animal or carcase, shall with all practicable speed give notice to a constable of the police force for the area wherein the animal or carcase is ; (2) the constable forthwith shall give information of such notice to the Inspector of the Local Authority, who shall forthwith report the same to the L. A. ; (3) the Inspector shall forthwith give information to the Medical Officer of Health of the Sanitary District in which the diseased or suspected animal or carcase is.

Article 3. (1) *Precautions to be taken by occupier in case of suspected anthrax. Occupier in such a case shall* (a) *prevent access of any animal or fowl to the suspected case, or to any part of his premises which has been exposed to infection, and* (b) *detain on his premises such diseased or suspected animal and any other animal which has been in the same shed, stable, building, yard, or field with such suspected animal : until it is certified that the animal or carcase was not diseased, or a notice is served on the occupier that his premises are an " infected " place within the meaning of the Diseases of Animals Acts ;* (2) *the occupier shall also disinfect as soon as possible with chloride of lime any place where the carcase of a diseased or suspected animal has lain or where its blood has escaped.*

Article 4. Lays down the duty of the Inspector of a Local Authority to act at once on information received concerning suspected anthrax. *He shall forthwith serve a notice in the form scheduled in this Order in terms of Article* 3.

Article 5. Veterinary Inquiry as to Existence of Anthrax :—

(1) A Local Authority shall forthwith cause inquiry to be instituted by a Veterinary Surgeon as to correctness of information.

(2) Owner or occupier of any premises on which such suspected case is shall give all reasonable facilities for such inquiry, under a penalty.

(3) *If the V. S. is satisfied at the time of his examination of the animal or carcase, by a microscopical examination of its blood on the spot, or by other evidence, that the animal or carcase was not diseased, he shall forthwith give to the L. A. a certificate to that effect, and the L. A., as soon as practicable, shall cause a notice to be served on the occupier of such premises in terms scheduled in the Order.*

(4) *If the V. S. is not so satisfied, he shall forthwith give to the L. A. a certificate stating that the case is one of suspected anthrax. He shall also for the purpose of further investigation take and examine one or more samples of the blood or other fluid of the animal or carcase, or of the tissue of the carcase, as may be necessary for that purpose, and as soon as may be after examination thereof forward to the Laboratory of the Board, Alperton Lodge, Wembley, Middlesex, such samples as may be required to enable a Veterinary Inspector of the Board to certify whether or not the animal or carcase was diseased, together with a report of his examination of the animal or carcase and of his further investigation.*

Article 6. *Where the V. S. gives to the L. A. a certificate that the case is one of suspected anthrax, the L. A. shall forthwith direct an Inspector to carry out such disinfection as the Inspector may deem necessary; and in the case of a carcase, to cause the same to be destroyed forthwith in the manner prescribed in this Order.*

Article 7. (1) *Where a Veterinary Inspector of the Board certifies that the animal or carcase was diseased, the L. A. on receipt of such certificate shall forthwith cause a notice in the form scheduled in this Order to be served by an Inspector on the occupier of the premises in which the case is or was, and thereafter the premises within the limits specified in the notice shall become an "infected place" for the purposes of this Order.*

(2) *A similar notice may be served on the occupier of any premises which in the opinion of the L. A. have been infected with disease by the animal or carcase, or exposed to infection therefrom.*

(3) *Where restrictions have been imposed by such a notice, the same shall continue in force until withdrawn by another notice in the form scheduled in this Order withdrawing the former notice.*

(4) *Where the Veterinary Inspector of the Board certifies that the animal or carcase was not diseased, the L. A. shall cause a notice to that effect, in the form scheduled in this Order, to be served on the occupier of the premises.*

(5) *A notice declaring premises to be an infected place shall not be served in relation to a market-place, fair-ground, sale-yard, place of exhibition, knacker's yard, or slaughter-house, except by direction of the Board.*

Article 8. *Directs that an Inspector shall with all practicable speed send copies of any of the above notices to the Secretary of the Board of Agriculture and Fisheries, 4 Whitehall Place, London, S.W., and to the police officer in charge of the nearest police station of the District, and in the case of notices declaring premises to be an infected place, or declaring a suspected animal or carcase not to be diseased, also to the Medical Officer of Health.*

Article 9. *Declares that the occupier of an infected place shall prevent access of animals to the diseased or suspected animal or carcase, or to any part of the premises which has been exposed to infection from the same; shall not move animals, or allow animals to stray out of or into the infected place, except as expressly authorised by this Article. Any horse, ass, mule, or dog, not diseased or suspected, may be so moved, and any animal, not diseased or suspected, may be moved out of the infected place to the nearest available slaughter-house under supervision of an Inspector or other officer of the L. A. for purposes of immediate slaughter, or by permission in writing of such Inspector to some premises which shall thereupon be declared an infected place in the manner indicated in Article 7.*

Litter, dung, broken fodder, utensils, pens, hurdles, or other things shall not be removed from the infected place except by written permission of an Inspector to the L. A.

Article 10. (1) A diseased carcase and any other carcase required by this Order to be destroyed shall be disposed of by the L. A. as follows:—

(*a*) The L. A. shall cause the carcase to be destroyed by exposure to a high temperature upon the farm or premises upon which the carcase is, or upon the nearest available premises suitable for that purpose; or (*b*) if authorised by the Board, the L. A. may, under the supervision of an officer of the L. A., cause the carcase to be destroyed in the manner following:—the carcase shall be disinfected, and shall then be taken to premises approved by the Board, and shall there be destroyed by exposure to a high temperature, or by chemical agents; or (*c*) where neither of the afore-named methods are available, the L. A. shall cause the carcase to be buried as soon as possible in its skin in some convenient or suitable place to which animals will not have access, and which is removed from any dwelling-house, and at such a distance from any well or watercourse as will preclude any risk of contamination of the water therein, the carcase being buried at a depth of not less than six feet below the surface of the earth, and with a layer of lime not less than one foot deep both beneath and above it. Where possible, the place of burial shall be the farm or premises upon which the animal died or was slaughtered.

(2) A diseased or suspected carcase shall not be buried or destroyed otherwise than by the L. A., or be removed from the farm or premises upon which the animal died or was slaughtered except by the L. A.

Before removal for burial or destruction, all the natural openings of the body of the animal shall be effectually plugged with tow or some suitable material soaked in a saturated solution of carbolic acid or other disinfectant equal in disinfective efficiency. In no case shall the skin be cut, nor shall anything be done to cause effusion of blood, except by a V. S. acting under directions of the L. A., and so far only as may be necessary for microscopical or cultural examination purposes : *Provided that nothing in this paragraph shall prevent a V. S. on behalf of the owner from taking a sample of the blood, or other fluid, or tissue, from the carcase for such examination in any case in which neither the history of the case nor any external lesions point to the existence of anthrax.*

The L. A. may cause or allow a carcase to be taken into the district of another L. A. to be buried or destroyed, with the previous consent of that L. A., but not otherwise.

Article 11. *The milk of any diseased or suspected cow or goat shall not be mixed with other milk, and all milk affected by the terms of this Article shall be boiled or otherwise sterilised, and any utensil in which such milk is placed before being so treated shall be thoroughly cleansed with boiling water before any other milk is placed therein.*

Article 12. It shall not be lawful, except with the licence of the Board or permission in writing of an Inspector of the Board, to dig up or cause to be dug up, the carcase of any animal buried, whether in terms of this Order or otherwise.

Article 13. (1) The L. A., at their own expense, shall cause to be cleansed and disinfected under direction of an Inspector, and in the mode prescribed in this Article—

(*a*) All parts of any place or premises in which a diseased animal has died or been slaughtered, or has been kept at the date of such death or slaughter ; (*b*) every utensil or thing used for or about any such diseased animal or carcase ; (*c*) every van, cart, or other vehicle used for carrying any diseased animal or carcase on land otherwise than on a railway.

(2) Any part of a place or thing so required to be disinfected by this Order shall be cleansed and disinfected in manner following :—

(*a*) Such part of a place or thing shall be thoroughly soaked or drenched with a 4 per cent. (minimum) solution of carbolic acid, containing not less than 95 per cent. of actual carbolic acid ; then (*b*) such part of a place or thing shall, if the nature thereof so permit, be scraped and, where necessary, swept ; and the scrapings and sweepings, and all dung, sawdust, litter, and other matter, shall be effectually removed therefrom ; then (*c*) such part of a place or thing shall be thoroughly washed or scrubbed or scoured with water, and then thoroughly coated or washed with (1) 1 per cent. (minimum) solution of chloride of lime, containing not less than 30 per cent. available chlorine, or (2) 4 per cent. (minimum) solution of carbolic acid (of above strength) followed by a thorough sprinkling with limewash, or (3) a disinfectant equal in disinfective efficiency to such solution of carbolic acid, followed by a thorough sprinkling with limewash.

(3) All scrapings and sweepings, and the dung, etc., shall be forthwith burned or otherwise destroyed ; and if destruction is not practicable, to be well mixed with quicklime and removed from contact with animals.

(4) The L. A., at their own expense, shall cause any litter, dung, or broken fodder which appears to them or their Inspector to be likely to spread disease, to be disinfected or destroyed, or to be burned or destroyed if impracticable to disinfect thoroughly.

(5) *Where cost of disinfection has been increased by any wilful act or neglect*

of owner of animal or carcase, the L. A. shall be entitled to recover from the owner such additional cost so caused.

Article 14. (1) Declares that the occupier of any place and the owner of any thing liable to be cleansed and disinfected in terms of this Order shall give all reasonable facilities to the L. A. for that purpose, under a penalty.

(2) *L. A. may by written notice of an Inspector and served on such occupier or owner, require him to cleanse and disinfect any such premises or any such thing at the expense of the L. A., and any such person failing thereafter so to do shall be guilty of an offence.*

Article 15. Makes it unlawful for any person (1) to expose a diseased or suspected animal in a market or fair, or in a sale-yard, or other public or private place where animals are commonly exposed for sale; or (2) to place such an animal in a fair or other place adjacent to or connected with such a place: or (3) to send, carry, or cause to be sent or carried, any such animal on a railway, canal, river, or inland navigation, or in a coasting vessel; or (4) to carry, lead, or drive, etc., any such animal on a highway or thoroughfare; or (5) to place or keep any such animal on common or unenclosed land, or in a field or place insufficiently fenced or adjoining a highway, unless that field is so fenced or situated that animals therein cannot in any manner come in contact with animals passing along that highway or grazing on the sides thereof; or (6) to graze any such animal on pasture on the sides of a highway; or (7) to allow any such animal to stray on a highway or thoroughfare or on sides thereof, or to be on common or unenclosed land, or in a field or place insufficiently fenced.

Notwithstanding anything in this Order, an animal exposed or otherwise dealt with in contravention of this Article may be moved by or under the direction of an Inspector of the L. A., to some convenient and isolated place.

Article 16. Declares that any powers by this Order conferred upon a L. A. or an Inspector of a L. A., may at any time be exercised by the Board or an Inspector of the Board respectively.

Article 17. Enacts that the provisions of this Order, except wherein it is otherwise provided, shall be executed and enforced by the L. A.

Article 18. Where the existence of anthrax is certified under Article 5 of this Order by a Veterinary Inspector of the Board, an Inspector of the L. A. shall forthwith make a return thereof to the L. A. and to the Board, with all particulars therein required, and shall continue so to do weekly until the disease has ceased.

Article 19. Horses, asses, mules, *and dogs* (as well as the animals specified in the Diseases of Animals Act of 1894) shall be animals, and anthrax (that is to say, the disease called or known as anthrax, splenic fever, or splenic apoplexy of animals) shall be a disease for the purposes of Sections 43 and 44 of the Act of 1894, and also for the purposes of all other sections of that Act which contain provisions relative to or consequent on the provisions of the aforenamed sections and of this Order.

Article 20. Declares that where the owner or person in charge of an animal is charged with an offence against the Act of 1894 relative to anthrax, he shall be presumed to have known of the existence of that disease, unless and until he shows, to the satisfaction of the Court, that he had not knowledge thereof, and could not with reasonable diligence have obtained that knowledge.

Article 21. Deals with such acts or omissions in contravention of this Order as are held to be offences against the Act of 1894.

Article 22. Revokes the Order of 1899.

Article 23. Extends this Order to England and Wales and Scotland.

Article 24. Declares that this Order shall come into operation on 1st Jan., 1911.

Article 25. This Order may be cited as the **Anthrax Order of 1910.**

The First Schedule gives the Forms of Notices referred to in the preceding Articles, and the Second Schedule revokes the Order of 1899.

Note.—The parts of this Order printed in *italics* are new. **Article 10** has been altered and rearranged. In the Order of 1899, the carcase was to be buried, or, alternatively, was to be removed under charge of an officer of the L. A. to a knacker's yard or other suitable place, and there be destroyed by subjecting it to exposure to a high temperature or by chemical agents. In the present Order, it is only to be buried where the circumstances do not permit of exposure to high temperature or treatment by chemical agents. **Article 11** of the present Order alters the mode of dealing with the milk of a cow suffering from anthrax. In the Order of 1899, it was only held to be unlawful to remove the milk of such an animal from the shed or other place in which the animal was kept. **Article 13**, which deals with cleansing and disinfection of premises, is more specific than the provisions of the Order of 1899 respecting the kinds and disinfective efficiency of the disinfectants to be employed.

APPENDIX II

DISPOSAL OF THE DEAD

I. SCOTLAND

A. Of the Infectious Dead.

Special enactments have been made respecting the temporary disposal and transportation of the bodies of persons who have died from infectious diseases, in order to prevent propagation of such diseases.

1. The practice of "waking" the dead body of any person who has died from infectious disease has been made penal in the **Public Health (Scotland) Act, 1897, section 56,** clause *d* (see p. 462).

Section 62. Prohibits the body of any person who has died of any infectious disease to be retained unburied for more than 48 hours elsewhere than in a room not used as a dwelling-place, sleeping-place, or workroom, except with the written sanction of the medical officer or of a legally qualified medical practitioner (see p. 462).

Section 63. Enacts that if a person dies in a hospital or place of temporary accommodation of the sick from *any* infectious disease, and the medical officer or other legally qualified medical practitioner certifies that it is desirable, in order to prevent the risk of spreading the disease, that the body should not be removed from such hospital or place except for the purpose of being forthwith buried, it shall not be lawful to remove the body except for that purpose, and, when so removed, the body shall be forthwith taken to the place of burial and be there buried (see p. 478).

Section 69. Provides that where the body of a person dead of any infectious disease is retained in a room in which persons live or sleep, where the body of any such person is retained longer than 48 hours without the sanction of the medical officer or legally qualified medical practitioner elsewhere than in a room not used at the time as a dwelling-place, sleeping-place, or workroom; or any dead body is retained in any house, or room, or *ship* under circumstances which, if continued, may endanger the health of the inmates thereof or of any adjoining or neighbouring house or building; or where any dead body within the district is unclaimed, or no sufficient person undertakes to bury it: a Sheriff, Magistrate, or Justice may, on a certificate signed by a medical officer or legally qualified medical practitioner, order the body to be removed to a mortuary, and may, if it is the body of a person who has died from infectious disease, or if he considers immediate burial necessary, direct that the body be buried immediately without removal to the mortuary. Should the friends or relations of deceased not bury the body in the time directed, the Local Authority shall do so, and may recover expenses from the person legally liable to pay the expenses of such burial.

Transportation of any infectious dead body by railway or other public conveyance, other than in a conveyance set apart for that purpose, and until the medical officer or a legally qualified medical practitioner has certified that the necessary precautions for the public safety have been taken, is forbidden under a penalty.

Section 79. Gives power to the Local Government Board in the case of a dangerous epidemic outbreak in the country to make regulations for the speedy interment of the dead (see p. 481).

The Cholera, Plague, and Yellow Fever Order, 1898, article 17, declares that in the event of any death from cholera, plague, or yellow fever taking place on board any infected ship at anchorage at the place fixed for that purpose, the master of the ship shall, as directed by the Local Authority or the medical officer of health, either cause the dead body to be taken out to sea and committed to the deep, properly loaded to prevent its rising, or shall deliver it into the charge of the L. A., who shall thereupon cause the same to be otherwise lawfully and properly disposed of.

According to the General Sanitary Regulations adopted by the **Convention of Venice** for Prevention of Plague, chap. IV., the corpses of plague-stricken patients should be wrapped in a shroud impregnated with corrosive sublimate and thrown into the sea.

In the Regulations issued by the Home Secretary in virtue of the powers contained in section 7 of the **Cremation Act, 1902**, it is declared that in the case of any person dying of plague, cholera, or yellow fever on board ship or in a hospital or temporary place of reception of the sick, the medical referee under the Act, if satisfied of the cause of death, may dispense with the ordinary requirements for cremation; and the regulations may be temporarily suspended or modified in any district by the Secretary for Scotland on application of a L. A. during an epidemic, or for other sufficient reason.

B. Of the Dead from other Causes.

Burial-Grounds (Scotland) Act, 1855.

Section 2. Enacts that parochial Boards shall carry this Act into execution; in parishes by the parochial Boards, and in parishes within the limits of any burgh the Town Council shall be held to be the parochial Board.

Section 3. That where any parish is partly within and partly without the limits of any burgh, the Sheriff of the county, on an application to him by any two members of the parochial Board, or by any *ten* poor-rate payers within such parish, or by any two or more householders residing within 100 yards of any burial-ground or proposed burial-ground within such parish, and after due notice in *The Edinburgh Gazette* and local newspapers, may hear parties having an interest, and may determine whether such parish shall be held to be a parish within or without the limits of such burgh, and his interlocutor so determining shall be as valid as if the same were set forth in this Act; and it shall not be competent to make any such new application till after the lapse of five years from date of last determination by the Sheriff.

Section 4. That it shall be lawful for any of the forenamed persons as grouped, to present a petition to the Sheriff of the county within which a burial-ground or proposed burial-ground is situated, setting forth that a burial-ground within such parish or distance is or would be dangerous to health, or offensive or contrary to decency, and the Sheriff shall thereupon fix a day, not more than 20 days after such petition is presented, for inquiring into the allegations therein contained, intimation of the same to be made as before, and, on hearing the petition, shall permit all interested parties to appear; and if thereafter he shall be of opinion that such allegations are true, he shall issue an interlocutor to such effect, and shall transmit a copy thereof to one of H. M.'s Principal Secretaries of State.

Section 5. That on representation of a Secretary of State, his Majesty in Council may restrain the opening of a new burial-ground and order discontinuance of burials in places specified, but no such Order in Council (section 7) shall be deemed to extend to any burial-ground of the people called Quakers or of persons of the Jewish persuasion, or to any private non-parochial burial-ground, unless the same be expressly mentioned in such Order.

Section 8. That notwithstanding such Order, it shall be lawful for a Secretary of State, on application to him by any person having a right to bury within any churchyard or burial-ground affected by such Order, and on being satisfied that the exercise of such right will not be injurious to health, to grant licence to exercise such right subject to such conditions as he may think fit.

Section 9. That although no burial-ground in a parish has been closed by Order in Council, the inspector of poor of a parish not within a burgh, and the Town Clerk in the case of a parish within a burgh, on requisition in writing of ten or more poor-rate payers or of any two or more members of the parochial Board, shall convene a special meeting of the parochial Board of such parish for the purpose of determining whether a burial-ground shall be provided under this Act for the parish, and if a majority of such meeting shall resolve that a burial-ground should be provided, such new burial-ground shall be provided in the same manner as if an old burial-ground had been closed by Order in Council.

Section 10. That where a burial-ground has been closed by Order in Council, the parochial Board shall forthwith proceed to provide a suitable and convenient burial-ground for the parish, and if such be not so provided within six months after such Order or requisition as aforesaid, any ten or more ratepayers, or any two or more members of the parochial Board, may apply to the Sheriff by summary petition to have a suitable portion of land designated for such purpose; and the Sheriff shall examine such witnesses and make such inquiry as he shall think proper, shall keep a note of such evidence, and, if he thinks fit, shall thereupon proceed to designate and set apart such portion as he may deem necessary of any lands in such parish suitable for the purpose, not being part of any policy, pleasure-ground, or garden attached to any dwelling.

Section 11. That no ground not already used as or appropriated for a cemetery shall be appropriated as a burial-ground, or as an addition to a burial-ground, under this Act, nearer than 100 yards to any dwelling-house, without the consent in writing of the owner, lessee, and occupier of such dwelling-house.

Section 12. That the parochial Board may purchase land for cemeteries, or may contract with any cemetery company.

Section 14. That parochial Boards may combine in providing a burial-ground for the common use of their parishes.

Section 17. That the general management, regulation, and control of burial-grounds, subject to the provisions of this Act and the regulations to be made thereunder, shall be vested in and exercised by the respective parochial Boards providing the same.

Section 18. That parochial Boards may sell exclusive rights of burial and right to erect monuments, but such exclusive rights shall not extend in all to a space greater than one-half of the burial-ground.

Section 19. That parochial Boards may make arrangements for facilitating the conveyance of bodies to burial-grounds.

Section 20. That parochial Boards may provide places for the reception of bodies until interment.

Section 21. That a Secretary of State may make regulations as to burial-grounds and places of reception of bodies previous to interment, for the protection of the public health and the maintenance of public decency; and parochial Boards shall conform to and obey such regulations; and

Section 31. That all burials within any burial-ground provided under this Act shall be registered in a register-book to be provided by the parochial Board and kept for that purpose; and in such register-books shall be distinguished in what parts of the burial-ground the several bodies are buried: said register-books to be kept or indexed so as to facilitate searches for entries in respect of the burial of such bodies, and to be received in all Courts as evidence of the burials entered therein.

[*Note.*—(*a*) The sections of the foregoing Act which have been omitted have a more or less legal bearing only.

(*b*) Section 146 (2) of the Public Health (Scotland) Act, 1897, makes it competent for the Local Government Board, or for any Local Authority, or for any Parish Council, to petition the Sheriff under section 4 of the Burial Grounds (Scotland) Act, 1855, and thereby amends that section (see also p. 515).

(*c*) Parochial Boards were abolished and "parish councils" substituted therefor by the Local Government (Scotland) Act.]

Bye-laws for the Regulation of Cemeteries.

The following bye-laws, which are in operation in Glasgow, after approval by the Secretary for Scotland, may be taken as typical of bye-laws relating to burial-grounds in Scotland :

(1) " Grave " means a burial-place formed in the ground by excavation, and without any internal wall of brickwork or stonework, or any other artificial lining ; " vault," includes burial-places of every description except graves to which the word " grave," interpreted as aforesaid, applies ; " person " shall include any person or individual or combination of persons.

(2) Every burial-ground shall be effectually fenced, and, if necessary, underdrained to such a depth as will prevent water remaining in any grave or vault.

(3) The area to be used for graves shall be divided into grave-spaces, to be designated by convenient marks, so that the position of each may be readily determined, and a corresponding plan kept in which each grave-space shall be shown.

(4) A register of graves shall be kept, in which the name, age, and date of burial in each shall be duly registered.

(5) A person shall not, in excavating a grave in any cemetery, cause or suffer to be left between such excavated grave and the nearest part of any coffin in any adjacent grave, *less than one foot of solid earth* ; or cause or suffer to be interred any coffin *nearer than eighteen inches laterally* to the nearest part of any other coffin.

(6) A person shall not, in any part of a cemetery, cause or suffer the body of a person, whose age at the time of death did not exceed *twelve years*, to be buried in a grave in such a manner as to require or allow any part of the coffin containing the body to be placed at a less depth than *three feet* below the level of the surface of the ground adjoining the grave.

(7) Is the same as (6), except that where the age *exceeds twelve years*, the depth shall be *not less than four feet* below the surface of the ground.

(8) A person shall not, in any part of a cemetery, cause or suffer the body of any person to be buried in any grave in which the body of any person has been previously buried, in such a manner as to disturb the earth upon or around the coffin containing such body, for the space of *one foot* above such coffin.

(9) A person shall not, etc., cause a body to be buried in a grave otherwise than in such a manner as to provide, by means of a sufficient layer or layers of earth which shall throughout be closely rammed down and be not less than *one foot* in thickness, for the effectual separation of the coffin containing the body from any coffin already placed in the grave.

(10) A person shall not, etc., cause or suffer the coffin of any person deposited in any grave to remain exposed, but shall forthwith cover it with a layer of earth, which shall throughout be closely rammed down and be not less than *one foot* in thickness ; and every coffin shall be covered before the expiry of the working hours of the day of burial with at least three feet of earth.

(11) A person shall not, etc., cause or suffer the coffin of any person to be broken up, or remove any portion of any coffin or any human remains from a grave, or disturb or remove any portion of the soil which shall be perceived to be offensive or impregnated with animal matter.

(12) Every person who buries a body in a grave in any part of a cemetery shall, as soon as reasonably may be after the lapse of such a period as may ordinarily suffice for the natural subsidence of the earth with which the grave has been filled up, cause the surface of the grave, in so far as not occupied by any grave-stone or other similar structure, to be properly dressed and covered with fresh turf, or shall cause the surface of the grave to be sown with grass, or planted with shrubs or other suitable vegetation.

(13) Every person who buries a body in a vault in any part of a cemetery shall either forthwith cause the coffin to be covered with dry porous earth to the depth of *two feet*, or within a period of twelve hours after burial cause the coffin to be wholly and permanently embedded in and covered with a layer or layers of good cement concrete not less in any part than *five inches* in thickness; or to be wholly and permanently enclosed in a separate cell or receptacle, which shall be constructed of slate or stone-flagging not less than two inches in thickness, properly jointed in cement, or of good brickwork in cement and in such manner as to prevent, as far as may be practicable, the escape of any noxious gas from the interior of such cell or receptacle.

(**14**) No person shall cause or suffer any portion of a cemetery which has been laid out as a road or footpath, or other means of access or approach, to be used for the purposes of burial, unless with the consent in writing of the Police Commissioners [or Parish Council].

(**15**) Every person who contravenes or fails to carry out any of the foregoing bye-laws, shall be liable to a penalty not exceeding £5 for each offence.

Glasgow, 27th April 1891.

II. ENGLAND AND WALES

A. Of the Infectious Dead.

"Waking" the dead in cases of infectious disease was made unlawful by section 68 of the **Public Health Acts Amendment Act, 1907** (**adoptive**).

The prohibition regarding retention of the body of any person who has died of any infectious disease elsewhere than in a mortuary or non-occupied room is laid down in section 8 of the **Infectious Disease (Prevention) Act, 1890**; the provision respecting the removal from hospital only for burial of the body of any person dying from infectious disease, in section 9 of the same Act, and for the Metropolis, in section 73 of the **P. H. (London) Act, 1891**; and the power of Justices to order in certain cases dead bodies to be buried, in section 10 of the Infectious Disease (Prevention) Act 1890 mentioned above.

Transportation of the body of a person who has died of an infectious disease in any public conveyance other than a hearse, without previous notification of that fact to the owner or driver, and the failure on the part of the owner or driver of any public conveyance other than a hearse used for such conveyance after such notification to have the conveyance efficiently disinfected, are offences under section 11 of the last-named Act and section 74 of the P. H. (London) Act, 1891.

The provisions with respect to deaths from cholera, plague, and yellow fever, and the application of the Cremation Act, 1902, thereto, apply equally to England and Wales as to Scotland (see p. 573).

B. Of the Dead from other Causes.

The law regarding burial and Cremation is contained in the

1. **Burial Acts, 1852–1906;**
2. **Public Health (Interments) Act, 1879**; and the
3. **Cremation Act, 1902, which applies also to Scotland.**

I. Burial Acts, 1852–1906.

The main provisions of these Acts, to which attention ought to be directed, are as follow:—

(*a*) **Burial Act**, 1853, enacts.—**Section 1.** That on the representation of a Secretary of State, his Majesty in Council may make an Order in Council forbidding the opening of any new burial-ground in any city or town, or ordering the discontinuance of burials in specified places: **Section 2.** That such Order shall not extend to burial-grounds of the Quakers or Jews unless such are expressly included in the Order: **Section 4.** That should an existing burial-ground be closed by Order in Council, any person having exclusive right of burial therein may apply to a Secretary of State, who may grant a licence to permit such person exercising his right to bury, under such conditions as he may choose to make, and provided that the exercise of such right shall not be injurious to health; **Section 5.** That this Act shall not apply to cemeteries or burial-grounds established by Act of Parliament; and **Section 8,** that a register of burials shall be kept in all burial-grounds, as in the Statute for Scotland (*q.v.*).

(*b*) Interment under or within the walls of any church was forbidden in the **Burial Act of 1848,** and this provision was incorporated in the **P. H. Act, 1875,** schedule V., part iii., as also were the provisions of other Burial Acts —viz. as to constitution of Burial Boards, and the power of urban Authorities constituted Burial Boards to repair fences surrounding burial-grounds, to prevent desecration of the same, to place such in a proper sanitary condition, and to pass bye-laws for their regulation and preservation.

(*c*) **The Burial Act, 1863.** Gave power to the Secretary of State for the Home Department to lay down regulations for grounds and cemeteries (*vide postea*).

(*d*) **The Disused Burial Grounds Act, 1864.** Made it illegal to erect any building upon a disused burial-ground except for enlargement of an existing place of worship.

(*e*) **The Burial Act, 1906.** Amended section 9 of the Burial Act, 1855, to read that the consent of the owner, lessee, and occupier of a dwelling-house to the use for burials of any ground used or appropriated for a burial-ground or cemetery shall not be required where the dwelling-house was begun to be erected or was completed after any part of that ground had been so used or appropriated. It amended also section 10 of the Cemeteries Clauses Act, 1847, as incorporated with the Public Health (Interments) Act, 1879, so that the distance from a dwelling-house of a proposed burial-ground should read "*one hundred yards*" instead of "two hundred yards."

II. Public Health (Interments) Act, 1879.

This Act enacts that the provisions of the Public Health Act, 1875, as to a place for the reception of the dead before interment, shall extend to a cemetery for interment of the dead, and shall include the acquisition, construction, and maintenance of a cemetery; that a Local Authority may acquire, construct, and maintain a cemetery either wholly within or partly within and partly without the district, the works as to a cemetery without the district being subject to the provisions of the Public Health Act, 1875, applicable to sewage works by a L.A. without their district; and a L.A. may accept any donation of land for a cemetery or of money or property to enable them to acquire, construct, and maintain a cemetery.

The Cemeteries Clauses Act, 1847, is incorporated in this Act, by which power is given to Burial Boards to obtain land by compulsory purchase for the construction and drainage of new cemeteries. When a new cemetery is constructed, the Cemeteries Clauses Act enacts (*a*) that no part of a cemetery (section 10) shall be constructed nearer than two hundred yards [*amended by the Burial Act,* 1906, *to* "*one hundred yards*"] to any dwelling-house, except with the consent in writing of the owner and occupier; (*b*) that the cemetery must be enclosed within suitable walls or railings not less than 8 *feet* in height; and (*c*) that the cemetery must be properly drained, and the drainage may be carried into any sewer with consent of those who have the management of such sewer.

III. Cremation Act, 1902.

This Act applies to England and Wales and Scotland, *but does not apply to Ireland.*

The main provisions of this Act are as follow:—

Section 2. "Crematorium" shall mean any building fitted with appliances for the purpose of burning human remains, and shall include everything incidental thereto.

Section 4. No human remains shall be burned in any crematorium until the site and plans have been approved by the L. G. Board, and the crematorium has been certified by the Burial Authority to the Secretary of State in England [or Secretary for Scotland in Scotland] to be complete, to have been built conform to such plans, and to be properly equipped.

Section 5. No crematorium shall be constructed nearer than 200 yards to any dwelling-house, except with the written consent of the owner, lessee, and occupier of such house, or within 50 yards of any public highway, or in the consecrated part of a burial-ground.

Section 6. Empowers a Burial Authority to accept donations of land or money to enable them to obtain a crematorium.

Section 7. The Secretary of State [or, the Secretary for Scotland] shall make regulations respecting the maintenance and inspection of crematoria, prescribing in what cases and under what conditions cremation may take place, directing the disposition or interment of the ashes, and prescribing the forms of the notices, certificates, and declarations to be given or made before cremation is permitted to take place.

Section 8. Declares penalties for contravention of any such regulations, making false declaration or representation, or signing or uttering any false certificate, or for procuring or attempting to procure cremation of any body with intent to conceal or impede the prosecution of any offence.

Regulations were made **for England** by the **Secretary of State** for the **Home Department** in virtue of section 7, dated 31st March 1903. These, paraphrased, are as follow :—

They declare *inter alia* : **1.** That no cremation of human remains shall take place except in a crematorium of the opening of which notice has been given to the Secretary of State ; **2.** That it shall not be lawful to cremate the remains of any person who is known to have left a written direction to the contrary ; nor to cremate human remains which are unidentified ; nor shall cremation be allowed until (1) death has been duly registered, except where an inquest has been held and a certificate in the schedule form E given by a Coroner, nor (2) unless application has been duly made therefor, and the particulars stated in the application be confirmed by statutory declaration, in accordance with the scheduled Form A. Such application must be signed and declaration made by an executor or by the nearest surviving relative of the deceased, or, if made by any other person, must show a satisfactory reason why such application was not made by such executor, etc.

3. No cremation shall be allowed to take place unless (1) a certificate in scheduled Form A be given by a registered medical practitioner who attended deceased during his last illness, and who can certify definitely as to the cause of death, and (2) a confirmatory medical certificate in scheduled Form C be given by another medical practitioner of not less than five years' standing, who must either (*a*) be appointed for the purpose by the Cremation Authority ; or (*b*) be a medical officer of health, police surgeon, certifying surgeon under the Factory and Workshop Act, 1901, Medical Referee under the Workman's Compensation Act, 1897 ; or (c) hold an appointment as physician or surgeon to a public general hospital containing not less than fifty beds ; or unless a post-mortem examination has been made by a medical practitioner expert in pathology appointed by the Cremation Authority or by the Medical Referee in case of emergency, and a certificate given in scheduled Form D ; or an inquest has been held and a certificate given by the Coroner in scheduled Form E.

4. No cremation shall take place except on the written authority of the Medical Referee in terms of schedule Form F. Every Cremation Authority shall appoint a Medical Referee and a Deputy Medical Referee, who must be a registered medical practitioner of not less than five years' standing, and must possess such experience and qualifications as befit him for such duties as these regulations require of him, the names of such Medical Referee and Deputy when appointed by Cremation Authority to be sent to the Secretary of State.

A Medical Referee, if he has personally investigated the cause of death may give a certificate in scheduled Form C, and if he has made a post-mortem examination, a certificate in scheduled Form D; and if he be a Coroner, he may himself give the Coroner's certificate in scheduled Form E.

5. A Medical Referee shall not allow any cremation to take place, (*a*) if it appears that deceased left a written direction to the contrary, (*b*) unless he is satisfied that the death has been duly registered by the production of a "certificate of registry of death" on the proper form, (*c*) unless application has been duly made as aforesaid by the executor or nearest surviving relative of deceased, or, if not by one of these, if the person applying is a proper person to do so, (*d*) unless he is satisfied that the fact and cause of death have been definitely ascertained, and, in particular, if the cause of death assigned in the medical certificates be such as might be due to any illegal operation or to privation or neglect, he shall require a post-mortem examination to be held, and if that fails to reveal the cause of death, he shall decline to allow the cremation unless an inquest be held and a Coroner's certificate be given in the scheduled Form E. If it appears that death was due to poison, to violence, or to any of the above-named causes, or if there is any suspicious circumstance whatever, he shall decline to allow the cremation unless an inquest be held, and a certificate be given by the Coroner in scheduled Form E.

A Medical Referee may in any case decline to allow cremation without stating the reason.

He shall, before allowing the cremation, examine the application and certificates, and ascertain that they are in proper order, and that the inquiry made by those giving the certificates has been adequate, and he may himself make such inquiry thereanent as he may think necessary.

6. In the case of the remains of a person who has died out of England, the Medical Referee may accept a declaration in manner of Form A if made before any person having authority in that place to administer an oath or to take a declaration, and may accept certificates in the scheduled Forms B, C, and D, if signed by medical practitioners possessing qualifications substantially equivalent to those prescribed.

The foregoing Regulations shall not apply to cremation of a body already buried for a year or more, but such remains may be cremated subject to conditions imposed by the Secretary of State; and the body of any still-born child may be cremated notwithstanding the foregoing regulations, it if be certified to be still-born by a registered medical practitioner after examination of the body, and if the Medical Referee after inquiry is satisfied that it was still-born.

In the case of any person dying of plague, cholera, or yellow fever on board ship, or in a hospital or temporary place of reception of the sick, the Medical Referee, if satisfied of the cause of death, may dispense with the ordinary requirements for cremation hereinbefore specified; and the regulations may be temporarily suspended or modified in any district by the Secretary of State on application of a Local Authority, during an epidemic, or for other sufficient reason.

7. The ashes of cremated remains shall be given into the charge of the person who applied for the cremation, if he so desires; but if he does not desire them, they shall be decently interred by the Cremation Authority.

8. Every Cremation Authority shall appoint a registrar who shall keep a register of all cremations carried out by the Cremation Authority in the scheduled Form G, the entries relating to such cremation to be made immediately after the cremation has taken place, except the last entry, which shall be made as soon as the ashes have been handed to relatives or otherwise disposed of.

9. All registers and documents shall be open to inspection at any reasonable hour by any person appointed for that purpose by the Secretary of State, the Local Government Board, or the Chief Officer of any Police Force.

Regulations of Home Office for Burial Grounds or Cemeteries under the Burial Act, 1863.

These mainly deal with grave-spaces.

1. For the remains of persons over twelve years of age, the grave-space shall at least be 9 ft. by 4 ft. (4 square yards).

2. For the remains of persons under twelve years, the grave-space shall be either 6 ft. by 3 ft. or 4½ ft. by 4 (2 square yards).

3. There must be 1 ft. at least between each grave. With respect to the opening for interment in a grave of a body of another member of the same family, the regulations are alike to those hereinafter set down.

Model Bye-Laws issued by the Local Government Board under the powers of section 2 of the Public Health (Interments) Act, 1879.

1. "Grave". means a burial-place formed in the ground by excavation and without any internal wall of brick or stone, or any other artificial lining.

A "vault" includes underground burial-places of every description, except graves to which the word "grave" interpreted as above applies.

2. Every vault built for use as a burial-place must be enclosed with walls constructed of good brick, stone, or other hard and suitable material, properly bonded and solidly put together (*a*) with good mortar made of good lime and clean, sharp sand, or other suitable material, or (*b*) with good cement, or (*c*) with good cement mixed with clean, sharp sand.

3. Unless exclusive right of burial has been granted by the Local Authority, not more than one body shall be buried at one time in a grave; but this shall not be deemed to prohibit the burial at any one time in any grave of the bodies of two or more persons who are members of the same family.

4. No grave containing the body of a person under *twelve years* shall be opened, within a period of *eight years*, for the purpose of burying therein the body of a person who was not a member of the same family as the person already buried in the grave.

5. Where the age of the person buried *exceeds twelve years*, the time limit of opening for the interment of the body of another person not of the same family shall be extended to *fourteen years*.

6. Where the age of the person buried does not exceed twelve years, every part of the coffin containing the body of the second member of the same family must be at least *three* feet below the level of the ground.

7. Where the age of the person buried is *over twelve* years, every part of the second coffin must be at least *four* feet below the ground.

8. Where in any grave there is more than one coffin, they must be separated one from the other by a layer of earth, closely rammed down, of at least *one foot* thick.

9. Within twenty-four hours of depositing any body in any vault, the coffin must be surrounded with good cement-concrete at least *six inches* thick, or, alternatively, the coffin may be placed in a separate cell, composed either of slate or stone-flagging at least *two inches* thick, properly jointed in cement, or of good brick-work in cement, and in such manner as to prevent as far as practicable the escape of any noxious gas from the interior of the cell.

10. As soon as possible after burial in a grave in respect of which exclusive right of burial has been granted, the surface of the grave must be properly covered with fresh turf.

The other bye-laws have no direct reference to the public health.

Memorandum by Local Government Board, 1879.

The Local Government Board in this Memorandum pointed out to Sanitary Authorities that they should take action regarding the provision of a cemetery for their district under the Public Health (Interments) Act, 1879, when the following conditions prevailed in existing burial grounds—viz.

1. Where in any burial-ground that remains in use there is not proper space for burial, and no other suitable burial-ground has been provided.

2. Where the continued use of an existing burial-ground (notwithstanding there may be such space), owing to its situation in relation to the water-supply of the locality, or to any circumstances whatsoever, would be injurious to the public health.

3. Where, in order to protect the public health, it is expedient to discontinue burials in a particular town, village, or place, or within certain limits.

Where it is desirable, upon such grounds as the above, to close an existing burial-ground, a representation ought to be made to the Home Secretary to obtain an Order in Council to that effect, under the provisions of the Burial Act of 1853.

Memorandum by Local Government Board, 1906.

In this Memorandum the Board indicated the chief sanitary considerations to be kept in view in providing a cemetery or burial-ground—viz. (1) suitable soil and proper elevation of site ; (2) suitable position in relation to inhabited dwellings and to sources of water-supply ; (3) sufficient space for the population, present and in the future ; and (4) proper regulation and management.

III. IRELAND

The law is contained in the

Public Health (Ireland) Act, 1878 : Sections 160–199.

The substance of these sections may be summarised as follows :—

Section 160. Constitutes the Sanitary Authority, subject to the control of the Local Government Board, the Burial Board of its district, except in towns having Commissioners under local Acts, in which case the Guardians of the Poor-Law Union become the Burial Board for the town ;

Section 161. Vests all burial-grounds in the Burial Board ;

Section 162. Gives power to the L. G. Board, after representation or on their own initiative, (*a*) to prevent a new burial-ground to be opened except with their permission, (*b*) to cause burials to be discontinued in any burial-ground, or (*c*) to limit burials in any burial-grounds, and (*d*) to issue an Order to any such effect.

Section 163. When representation is made to the L. G. Board, or otherwise, the Board may cause a local inquiry to be held, notice of intention to hold such inquiry to be published three weeks beforehand, and to be affixed to church or chapel doors, and in some other conspicuous place within the parish in which the burial-ground referred to is situated. An inspector of the Board may conduct such inquiry and take evidence and report, and the Board may act upon such report as they see fit.

Section 164. Empowers the L. G. Board to postpone the time for putting in operation an Order to discontinue burial or to vary any such Order.

Section 165. Exempts burial-grounds used exclusively by Quakers unless expressly mentioned in any Order.

Section 166. Empowers the L. G. Board to grant special licences for interments in burial-grounds affected by any Order of the Board, or where exclusive right of interment has been purchased prior to the passing of the Burial Grounds (Ireland) Act, 1856, provided that no injury to the public health will result.

Section 169. Declares that where an Order of the L. G. Board prohibits the opening of a new burial-ground in any place without their approval, such approval must be obtained prior to opening such burial-ground.

Section 170. Enacts that no corpse other than that of a member of the family shall be buried in any family vault or grave without the written consent of some immediate relative of the last interred person, under a penalty; and the Court may order any such body to be exhumed and reburied elsewhere.

Section 171. Prohibits that any animal be permitted to graze or be within any burying-ground which is sufficiently fenced, the owner of such animal to be liable to pay a fine.

Section 172. Provides that although no burial-ground has been closed by Order of the L. G. Board, ten or more persons paying poor-rates, or two or more members of the Burial Board, may in writing request the clerk of the Burial Board to convene a special meeting to determine whether or not a burial-ground should be provided; and if a majority resolve that a new burial-ground is necessary, the after procedure to obtain it must be as if an old burial-ground had been closed by Order of the L. G. Board.

Section 173. Enacts that when a burial-ground has been closed by Order of the L. G. Board, the Burial Board may, if they deem it necessary or expedient so to do, provide such new burial-ground.

Section 174. Enacts that a burial-ground may be provided either within or without the limits of the district, and when provided, such shall be deemed to be within the limits of the district. No ground not already used or appropriated as a cemetery shall be used for burials if it be nearer than 100 yards to a dwelling-house, without the written consent of the owner, lessee, and occupier of such house.

Section 175. Empowers a Burial Board to purchase lands, buildings, etc., on which to construct cemeteries, or to purchase existing cemeteries, or to contract for interments of persons in their district.

Section 176. Declares that burial-grounds are to be under the management, regulation, and control of their respective Burial Boards.

Section 178. Empowers such Boards to sell rights of burial.

Section 179. Deals with the manner of conveying bodies to burial-grounds for burial.

Section 180. Empowers the Burial Board to provide places for reception of bodies until they are buried.

Section 181. Empowers the L. G. Board to make regulations for burial-grounds and places for reception of dead bodies in order to protect the public health and maintain public decency, for the proper registration of burials, and for recovery of penalties for contravention of such regulations.

Section 184. Empowers a Burial Board to extend burial-grounds, though not purchased under the provisions of this Act, provided the existing burial-ground is neither attached nor contiguous to a place of worship in actual use, nor is in private grounds.

Section 185. Empowers the Burial Board to call upon the owner of any burial-ground to fence and put it into decent order, if the cemetery is not in private grounds nor is attached to a place of worship.

Section 180. If the owner cannot be found, the Burial Board shall advertise in a local newspaper their intention to execute the necessary work at the end of six months, and after the work has been done, the management and control of the burial-ground shall pass into the hands of the Burial Board of the district.

Section 188. Deals with charges for burial.

Section 191. Ordains that a register of burials must be kept by the Burial Board, as in the English and Scottish Acts.

Establishment of a New Cemetery

When a Local Sanitary Authority has determined that a new cemetery is required for the district, they will turn to the medical officer of health for guidance on the subject. His advice will probably chiefly centre on the following four main points—viz.

1. Suitable soil and proper elevation of site; 2. Suitable position relative to dwelling-houses and to sources of water-supply; 3. Sufficient space; and 4. Proper regulation and management.

I. Suitable soil and proper elevation of site.

The objective point to be aimed at in inhumation is rapid innocuous dissolution of bodies, and complete oxidation and absorption of the products.

To produce colliquative putrefaction, the presence of air and of a certain range of temperature, together with moisture, are absolutely essential. Hence a soil should be looked for which is of a porous character so that ground-respiration may take place. Open, sandy or gravelly soils or loams are, therefore, the best. Rough, stony ground is unsuitable, because of the tendency of gases of decomposition to escape too freely. Clayey soils are most unsuitable. We have seen graves opened in such soil in which the fleshy parts of a corpse buried many years before were comparatively fresh. Such soils are unfitted for burial purposes because, by reason of their dense consistence, little or no interchange of air or ground-respiration can take place; besides, after long periods of drought, they are apt to become cracked or fissured sometimes to considerable depths, and thus may permit of the escape of gases of decomposition. For like reasons, peaty soil is unsuitable. The depth of the sub-soil water in a site is a factor of considerable importance; hence, before a site is finally chosen, experimental pits of varying depths should be dug to determine the depth of the sub-soil water in varying conditions of season and weather. It is necessary to choose a site in which the level of sub-soil water will not, even under the most unfavourable conditions, rise toward the ground-surface higher than the depth to which graves must be excavated; otherwise, colliquative putrefaction is apt to be arrested, and saponification, with the formation of adipocere, to take place. We have seen in such water-logged soil entire bodies converted into adipocere.

II. Suitable position relative to dwelling-houses and to sources of water-supply.—While it is desirable that there should be an elevation of site in order to secure efficient drainage of the burial-ground, such elevation must be considered in relation to the flow of sub-soil water to neighbouring inhabited dwellings, and to water-supplies from wells. Such points must be especially considered in connection with extension of churchyards where the vicarage or manse is adjacent to both. Several years ago, we photographed a drinking well situated within a grave-yard, which was then in actual use, but, doubtless, it has since been closed.

The position of a grave-yard is to some extent determined by the statutory enactments for the different sections of the United Kingdom. No cemetery must be established within 100 yards of a dwelling-house except with consent of the owner, occupier, and lessee of the dwelling. But even that distance may be entirely insufficient in certain localities owing to the natural trend of the sub-soil water, and to the source of the local water-supply, especially if that be obtained from wells. Speaking generally, cemeteries should be placed at some distance from existing buildings—even, when possible, considerably beyond the statutory requirements—and from likely future extensions of buildings. For populous centres, they should be well beyond the outskirts of the town or city, and should be easily accessible by road, or rail, or other conveyance.

III. Sufficient Space.—The usual grave-space for persons over twelve years of age being 9 ft. by 4 ft., the average requirements of ground per 1000 of population for 50 years is 1 acre. To this must be added a margin for roads and paths, and for spaces for decorative shrub-planting. Cemeteries should be laid down in grass, if the ground chosen be not already of old turf.

IV. Proper Regulation and Management.—It would, in view of the present state of public opinion, perhaps be impossible to insist upon the entire abolition of vaults, brick-lined graves, and such like structures, or of coffins made of dense wood, or coffins with inner "shells" of zinc or lead. Such, however, are but obstructants to the object and intention of burial, as are also cement-covered coffins in vaults and catacombs. All these retard the process of colliquative putrefaction, and tend somewhat to the production of adipocere. It were much better that bodies should be interred in a simple, deal coffin or one of wicker-work and in a grave, than in a dense wood or metal coffin or in any vault.

Cremation is, after all, merely a more rapid process of oxidation or combustion of the tissues, than that which takes place in burial under the best conditions. It offers many advantages in the sanitary disposal of the dead. It quickens the dissolution of the body and demands much less space in the disposal of the ashes, which, from the fire, are purged of all impurity.

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